DECLARATION

I, Masami AIZAWA, of SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1, Yaesu, Chuo-ku, Tokyo, Japan, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. Hei 10-266993 and that all statements made herein are true to the best of my knowledge.

Declared in Tokyo, Japan

This 14 th day of April, 2004

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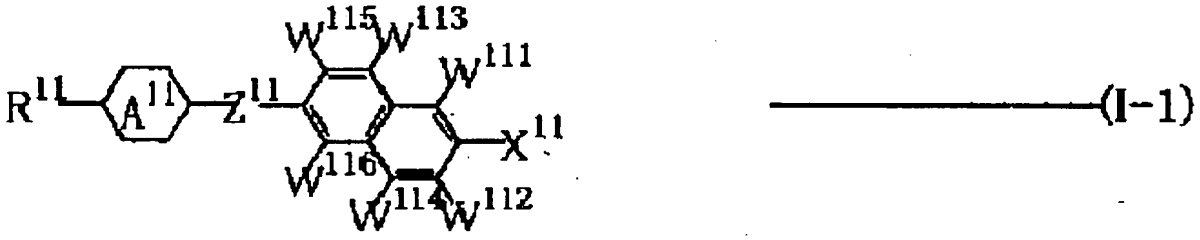
[Document Type] Specification

[Title of the Invention] NEMATIC LIQUID CRYSTAL COMPOSITION AND LIQUID CRYSTAL DISPLAY DEVICE USING THE SAME

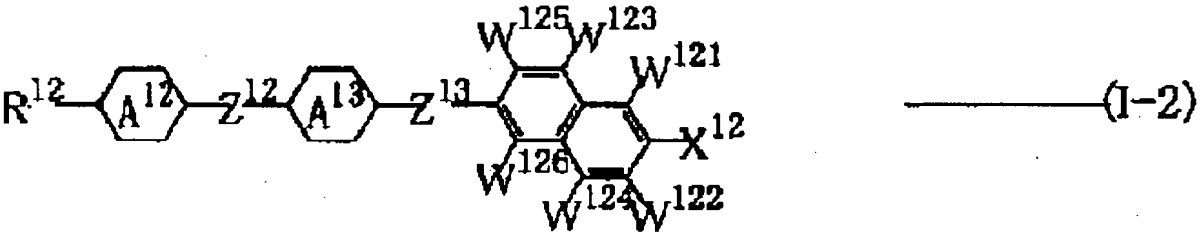
[Claims]

[Claim 1] A nematic liquid crystal composition comprising a liquid crystal component A composed of one, or two or more kinds of compounds represented by the general formulas (I-1) to (I-3):

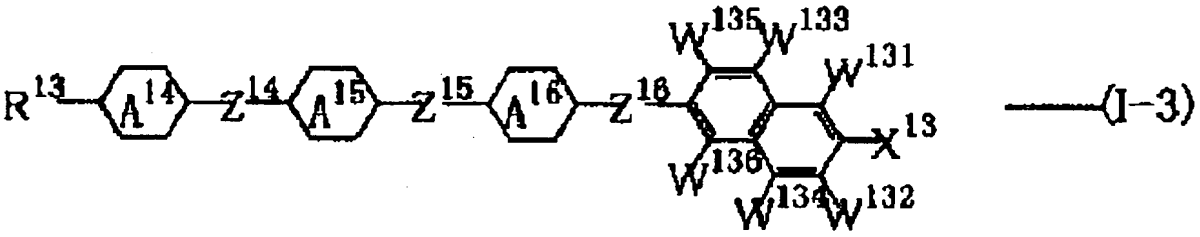
[Chemical Formula 1]



(I-1)



(I-2)



(I-3)

(wherein R^{11} to R^{13} each independently represents an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 10 carbon atoms, said alkyl or alkenyl group may have one F, CH_3 or CF_3 as a non-substituent or substituent group, or one, or two or more CH_2 group, which are present in said alkyl

or alkenyl group, each may be independently substituted with -O-, -CO- or -COO-, while O atoms do not bond with each other directly; X^{11} to X^{13} each independently represents F, Cl, CF_3, OCF_3, $OCFH_2$, NCS, or CN; W^{111} to W^{136} each independently represents H, F, Cl, CF_3, OCF_3, or CN; Z^{11} to Z^{16} each independently represents a single bond, -COO-, -OCO-, $-CH_2O-$, $-OCH_2-$, -CH=CH-, -CF=CF-, -C≡C-, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, or -N(O)=N-; and rings A^{11} to A^{16} each independently represents 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, 2,3-difluoro-1,4-phenylene, 3,5-difluoro-1,4-phenylene, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene, trans-1,4-cyclohexylene, or trans-1,4-dioxane-2,5-diyl, and hydrogen atoms of said rings may be substituted with a deuterium atom if said rings represent trans-1,4-cyclohexylene); 0 to 99.9% by weight of a liquid crystal component B composed of a compound having a dielectric constant anisotropy of +2 or more as a liquid crystal component excluding the compounds of the general formulas (I-1) to (I-3); and 0 to 85% by weight of a liquid crystal component C composed of a compound having a dielectric constant anisotropy within a range from -10 to +2; the sum total of said liquid crystal component B and said liquid crystal component C being within a range from 0 to 99.9% by weight.

[Claim 2] A nematic liquid crystal composition according to claim 1, wherein said liquid crystal component A contains

one, two or more kinds of compounds selected from compounds represented by the above general formula (I-1) or (I-2), the content of said compounds being within a range from 5 to 100% by weight in said liquid crystal component A.

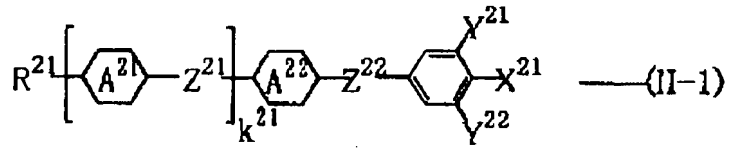
[Claim 3] A nematic liquid crystal composition according to claim 1, wherein said liquid crystal component A contains one, two or more kinds of compounds selected from compounds represented by the above general formulas (I-1) and (I-2), the content of said compounds being within a range from 5 to 100% by weight in said liquid crystal component A.

[Claim 4] A nematic liquid crystal composition according to claim 1, 2 or 3, wherein said liquid crystal component A contains one, or two or more kinds of compounds selected from compounds in which R^{11} to R^{13} each independently represents an alkyl or alkenyl group having 2 to 7 carbon atoms in the general formulas (I-1) to (I-3), compounds in which X^{11} to X^{13} each independently represents F, Cl, CF_3, OCF_3, OCF_2H or CN in the general formulas (I-1) to (I-3), compounds in which at least one of W^{111} to W^{113}, W^{121} to W^{123} and W^{131} to W^{133} is substituted with F in the general formulas (I-1) to (I-3), compounds in which Z^{11}, Z^{13} and Z^{16} each independently represents a single bond, $-(CH_2)_2-$, -COO- or -C≡C- in the general formulas (I-1) to (I-3), and compounds in which rings A^{11}, A^{13} and A^{16} each independently represents trans-1,4-cyclohexylene, 1,4-phenylene, 3-fluoro-1,4-phenylene or 3,5-difluoro-1,4-phenylene in the general formulas (I-1) to (I-3).

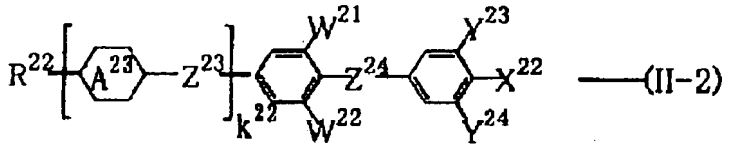
[Claim 5] A nematic liquid crystal composition according

to claim 1, 2, 3 or 4, wherein said liquid crystal component B comprises one, or two or more kinds of compounds represented by the general formulas (II-1) to (II-4):

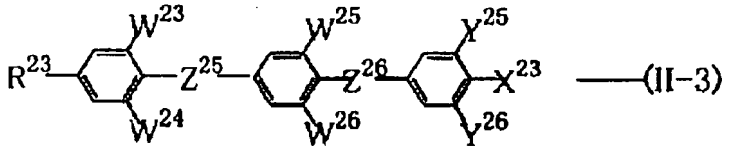
[Chemical Formula 2]



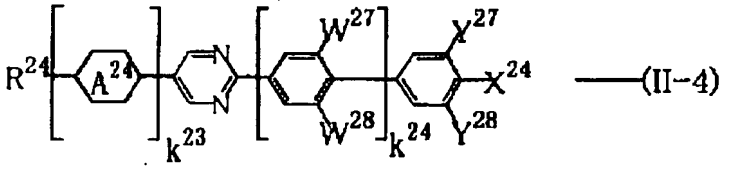
(II-1)



(II-2)



(II-3)



(II-4)

(wherein R^{21} to R^{24} each independently represents an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 10 carbon atoms, said alkyl or alkenyl group can have one F, CH_3 or CF_3 as a non-substituent or substituent group, or one, or two or more CH_2 groups, which are present in said alkyl or alkenyl group, each may be independently substituted with -O-, -CO- or -COO-, while O atoms do not bond with each other directly; X^{21} to X^{24} each independently represents F, Cl, CF_3, OCF_3, OCF_2H, NCS or CN; Y^{21} to Y^{28} each independently represents H, F, Cl or OCF_3; W^{21} to W^{28} each independently represents H, F or Cl; Z^{21} to Z^{26} each independently represents a single

bond, -COO-, -OCO-, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, -CH=CH-$(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, or -N(O)=N-, and also Z^{21}, Z^{24}, Z^{25} and Z^{26} may be -CH=CH-, -CF=CF- or $-C\equiv C-$; rings A^{21} to A^{24} each independently represents trans-1,4-cyclohexylene, trans-1,4-cyclohexenylene or trans-1,4-dioxane-2,5-diyl, and also the ring A^{24} may be 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or 3,5-difluoro-1,4-phenylene, and hydrogen atoms of said ring may be substituted with a deuterium atom if said ring represents trans-1,4-cyclohexylene; k^{21} to k^{24} each independently represents 0 or 1, and $K^{23}+k^{24}$ = 0 or 1).

[Claim 6] A nematic liquid crystal composition according to claim 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compounds in which R^{21} to R^{24} each independently represents an alkenyl group having 2 to 5 carbon atoms in the general formulas (II-1) to (II-4); compounds in which X^{21} to X^{24} each independently represents F, Cl or $-OCF_3$ in the general formulas (II-1) to (II-4); compound in which Z^{22} is $-(CH_2)_2-$ or $-(CH_2)_4-$ in the general formula (II-1); compound in which k^{21} is 1 in the general formula (II-1); compound in which at least one of Y^{23}, Y^{24}, W^{21} and W^{22} is F in the general formula (II-2), compound in which k^{22} is 1 and Z^{24} is $-C\equiv C-$ in the general formula (II-2), compound in which Z^{23} represents a single bond or $-(CH_2)_2-$ and Z^{24} is -COO- in the general formula (II-2); compound in which at least one of Y^{25}, Y^{26} and W^{23} to W^{26} is F in the general formula (II-3), compound in which Z^{26} represent $-C\equiv C-$ in the

general formula (II-3); compound in which Z^{25} represents a single bond or -C≡C- and Z^{26} is -COO- in the general formula (II-3); compound represented by the general formula (II-4); and compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said ring are substituted with a deuterium atom in the general formulas (II-1) and (II-2).

[Claim 7] A nematic liquid crystal composition according to claim 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compound in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 0 and X^{21} is -CN in the general formula (II-1); compound in which k^{21} is 1, X^{21} is F or -CN, and Y^{21} and Y^{22} represent H or F in the general formula (II-1); compound in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 0, X^{22} is -CN, and Y^{23}, Y^{24}, W^{21} and W^{22} each independently represents H or F in the general formula (II-2); compound in which k^{22} is 1, Z^{23} is a single bond, $-(CH_2)_2-$ or -COO-, Z^{24} is a single bond, -COO- or -C≡C-, X^{22} is F or -CN, and Y^{23}, Y^{24}, W^{21} and W^{22} each independently represents H or F in the general formula (II-2); compound in which R^{23} is an alkyl or alkenyl group having 2 to 5 carbon atoms, at least one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO- or -C≡C- in the general formula (II-3); compound in which Y^{25}, Y^{26} and W^{23} to W^{26} each independently represents H or F in the general formula (II-3); compound in which R^{24} is an alkyl or alkenyl group having 2 to 7 carbon atoms and $k^{23}+k^{24}$ is 0 in

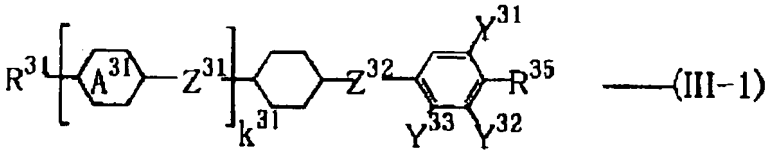
the general formula (II-4); and compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in the general formulas (II-1) and (II-2), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component B.

[Claim 8] A nematic liquid crystal composition according to claim 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compound in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 1, one of Z^{21} and Z^{22} is a single bond and other one is a single bond, -COO-, $-(CH_2)_2-$ or $-(CH_2)_4$, X^{21} is F, Cl, CF_3, OCF_3 or OCF_2H, and one or two Y^{21} and Y^{22} represent F in the general formula (II-1); compound in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 1, Z^{23} is a single bond, $-(CH_2)_2-$ or -COO-, Z^{24} is a single bond, -COO- or $-C\equiv C-$, X^{22} is F, Cl, CF_3, OCF_3 or OCF_2H, one or two Y^{23} and Y^{24} represent F, and W^{21} and W^{22} represent H or F in the general formula (II-2); compound in which R^{23} is an alkyl or alkenyl having 2 to 5 carbon atoms, one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO- or $-C\equiv C-$, X^{23} is F, one or two Y^{25} and Y^{26} represent F, and W^{23} to W^{26} each independently represents H or one or more of them represent F in the general formula (II-3); and compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in the general formulas (II-1) and (II-2), the content of said compounds

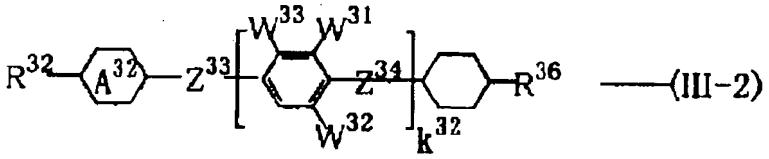
being within a range from 10 to 100% by weight in said liquid crystal component B.

[Claim 9] A nematic liquid crystal composition according to any one of claims 1 to 8, wherein said liquid crystal component C comprises one, or two or more kinds of compounds represented by the general formulas (III-1) to (III-4):

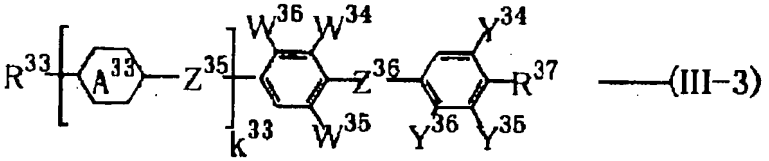
[Chemical Formula 3]



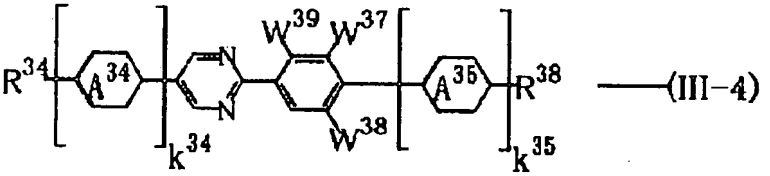
(III-1)



(III-2)



(III-3)



(III-4)

(wherein R^{31} to R^{38} each independently represents an alkyl or alkoxy group having 1 to 7 carbon atoms, or an alkenyl or alkenyloxy group having 2 to 7 carbon atoms, said alkyl group, said alkoxy group, said alkenyl group or said alkenyloxy group may have one F, CH_3 or CF_3 as a non-substituent or substituent group, or one, or two or more CH_2 groups, which are present in said alkyl or alkenyl group, each may be independently

substituted with -O-, -CO- or -COO-, while O atoms do not bond with each other directly; Y^{31} to Y^{36} each independently represents H or F, and also Y^{33} and Y^{36} may represent $-CH_3$; W^{31} to W^{39} each independently represents H, F or Cl; Z^{31} to Z^{36} each independently represents a single bond, $-COO-$, $-OCO-$, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, $-CH=N-$, $-CH=N-N=CH-$, or $-N(O)=N-$, and also Z^{31} and Z^{34} to Z^{36} may be $-CH=CH-$, $-CF=CF-$ or $-C\equiv C-$; rings A^{31} to A^{35} each independently represents trans-1,4-cyclohexylene, trans-1,4-cyclohexenylene or trans-1,4-dioxane-2,5-diyl, and also rings A^{31} and A^{33} to A^{35} may be 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, 2,3-difluoro-1,4-phenylene, or 3,5-difluoro-1,4-phenylene, and hydrogen atoms of said rings may be substituted with a deuterium atom if said rings represent trans-1,4-cyclohexylene; k^{31} to k^{35} each independently represents 0 or 1, and $K^{34}+k^{35}$ = 0 or 1).

[Claim 10] A nematic liquid crystal composition according to claim 9, wherein said liquid crystal component C contains one, two or more kinds of compounds selected from compound represented by the general formula (III-1), compound represented by the general formula (III-2) or compound represented by the general formula (III-3), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component C.

[Claim 11] A nematic liquid crystal composition according to claim 9, wherein said liquid crystal component C contains one, or two or more kinds of compounds selected from compounds

in which R^{31} to R^{34} represent an alkenyl group having 2 to 5 carbon atoms in the general formulas (III-1) to (III-4); compounds in which R^{35} to R^{38} represent a straight-chain alkenyl or alkenyloxy group having 2 to 7 carbon atoms in the general formulas (III-1) to (III-4); compound in which k^{31} is 0 and Z^{32} is a single bond or $-(CH_2)_2-$ in the general formula (III-1); compound in which k^{31} is 1 in the general formula (III-1); compound represented by the general formula (III-2); compound in which at least one of Y^{34}, Y^{35} and W^{34} to W^{36} is F and Y^{36} is F or $-CH_3$ in the general formula (III-3); compound in which k^{33} is 0 and Z^{36} is a single bond in the general formula (III-3); compound in which k^{33} is 1, Z^{35} is a single bond, $-OCO-$, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, $-CH=N-$, $-CH=N-N=CH-$, $-N(O)=N-$, $-CH=CH-$ or $-CF=CF-$ in the general formula (III-3); compound in which Z^{35} is $-COO-$ or $-C\equiv C-$ and Z^{36} is $-OCO-$, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, $-CH=N-$, $-CH=N-N=CH-$, $-N(O)=N-$, $-CH=CH-$, $-CF=CF-$ or $-C\equiv C-$ in the general formula (III-3); compound represented by the general formula (III-4); and compounds in which rings A^{31} to A^{35} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in compounds represented by the general formulas (III-1) to (III-4).

[Claim 12] A nematic liquid crystal composition according to claim 9, wherein said liquid crystal component C contains one, or two or more kinds of compounds selected from compound in which R^{31} is an alkyl group having 1 to 5 carbon atoms or an

alkenyl group having 2 to 5 carbon atoms, R^{35} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{31} is 0, and Z^{32} is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-1); compound in which k^{31} is 1, ring A^{31} is trans-1,4-cyclohexylene, one of Z^{31} and Z^{32} is a single bond and the other one is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-1); compound in which R^{32} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{36} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, ring A^{32} is trans-1,4-cyclohexylene or trans-1,4-cyclohexenylene, k^{32} is 0 and Z^{33} is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-2); compound in which k^{32} is 1 and one of Z^{33} and Z^{34} is a single bond in the general formula (III-2); compound in which R^{33} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{37} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{33} is 0 and Z^{36} is a single bond, -C≡C- or -CH=N-N=CH- in the general formula (III-3); compound in which k^{33} is 1, Z^{35} is a single bond, $-(CH_2)_2-$, -COO- or -C≡C- and Z^{36} is a single bond, -COO- or -C≡C- in the general formula (III-3); compound in which one of Z^{35} and Z^{36} is a single bond and the other one is a single bond or -C≡C- and at least one of W^{34} and W^{35} is F in the general formula (III-3); compound in which one of Y^{35} and Y^{36} is substituted with F and CH_3 in the general formula

(III-3); and compound in which R^{34} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{38} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms and $k^{34}+k^{35} = 0$ in the general formula (III-4), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component C.

[Claim 13] A nematic liquid crystal composition according to any one of claims 1 to 12, wherein said liquid crystal composition contains one, or two or more kinds of core-structure compounds which have four six-membered rings and a liquid crystal phase-isotropic liquid phase transition temperature of 100°C or higher.

[Claim 14] A nematic liquid crystal composition according to any one of claims 1 to 13, wherein said liquid crystal composition has a dielectric constant anisotropy within a range from 4 to 30, a birefringent index within a range from 0.08 to 0.35, a nematic phase-isotropic liquid phase transfer temperature within a range from 50 to 180°C or higher, and a crystal phase-, smectic phase- or glass phase-nematic phase transfer temperature within a range from -200 to 0°C.

[Claim 15] A nematic liquid crystal composition according to any one of claims 1 to 14, wherein said liquid crystal composition contains a compound having an optically active group capable of securing an induced helical pitch within a range from 0.5 to 1000 μm.

[Claim 16] An active matrix, twisted nematic or super

twisted nematic liquid display device using the nematic liquid crystal composition of claim 15.

[Claim 17] A light scattering type liquid display device comprising a light modulation layer which contains the liquid crystal composition of any one of claims 1 to 15 and a transparent solid substance.

[Claim 18] A light scattering type liquid display device according to claim 17, wherein said liquid crystal composition formed a continuous layer in said light modulation layer and said transparent solid substance formed a uniform three-dimensional network in said continuous layer.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to nematic liquid crystal compositions which are useful as electro-optical display materials, and a liquid crystal display device using the same.

[0002]

[Prior Art]

Representative liquid crystal display elements include TN-LCDs (twisted nematic liquid crystal display element), that is used in clocks, electronic calculators, handheld organizers, pocket computers, word processors and personal computers. As the volume of information processed by office automation equipment increased, the STN (super twisted nematic) LCD was developed by Scheffer et al. (SID '85 Digest, p. 120, 1985) and Kinugawa et al. (SID '86 Digest, p.

122, 1986), and found wide use in portable terminals, handheld organizers, pocket computers, word processors, personal computers and display terminals for sophisticated information processing.

[0003]

Recently, the active addressing drive method (Proc. 12th IDRC p. 503, 1992) and multi-alignment addressing drive method (SID '92 Digest, p. 232, 1992) have been proposed for improving the response characteristics of STN-LCDs. For the purpose of providing displays with a higher brightness and higher contrast ratio, the use of a modified reflection type color LCD display method (Television Association Technical Report, vol. 14, No. 10, p.51, 1990) that utilizes the birefringence of a liquid crystal and a retardation plate instead of a color filter, and a liquid crystal display device provided with a reflecting surface having small parabolic surfaces formed on the substrate electrode side have been proposed.

[0004]

For application to large display areas, in particular, it is required to achieve uniformity of the display, despite the temperature distribution of the backlight, and high contrast. This calls for a liquid crystal material that has more stable orientation and lower dependence on the temperature, or an appropriate birefringent index for limiting the variations in the cell thickness. Also because the display is driven with a higher duty ratio as the number of pixels increases, it is

required to improve the response characteristics and the display tone characteristics accordingly. For the medium- and small displays for portable applications, on the other hand, it is important to achieve stability of the display regardless of the operating temperature. This calls for a liquid crystal material that allows a lower driving voltage in order to improve the response characteristics and reduce the power consumption, lower temperature dependence of the driving voltage in extreme temperature ranges from -30 to 0°C and 40 to 80°C, higher sharpness and lower frequency dependence for driving with the desired duty ratio in the temperature range. Moreover, although it should be avoided to make the electric resistance (resistivity) of the liquid crystal too low to decrease the power consumption, the resistivity should be set to a proper level that is not high enough to cause burning of the display. Thus there still remain various requirements for improved liquid crystal materials having slightly different characteristics that are different from each other.

[0005]

For this purpose, the liquid crystal material is required to have an optimized set of characteristics including physical properties such as birefringent index, elastic constant, dielectric constant anisotropy, lower viscosity, broader nematic temperature range, chemical stability and electrical stability (a desired resistivity and voltage holding ratio), a pre-tilt angle related to the orientation and a wider d/p margin. Accordingly, there are still demands for new liquid

crystal compounds and liquid crystal compositions.

[0006]

Meanwhile, active matrix liquid crystal display devices have been used for such applications as portable terminals, liquid crystal television screens, projectors and computers, by taking advantage of the high display quality thereof. In the active matrix liquid crystal display device, a TFT (thin film transistor), an MIM (metal-insulator-metal) element or the like is used for each pixel, and a high voltage holding ratio is required for this display method. For the purpose of achieving a wider viewing angle, a super TFT that combines the IPS mode was proposed by Kondo et al. (Asia Display '95 Digest, p. 707, 1995). (The liquid crystal display elements of the active matrix display method will be hereinafter collectively referred to as TFT-LCDs.) In order to provide for such new display elements, various proposals have been made of new liquid crystal compounds and new liquid crystal compositions, such as Japanese Unexamined Patent Application, First Publication No. Hei 2-233626 and Published Japanese Translation No. Hei 4-501575 of the PCT Application.

[0007]

In order to provide for a TFT-LCD based on polysilicon technology, which has been a focus of attention recently, there are demands for a liquid crystal material having a higher voltage holding ratio and higher immunity to staining, a liquid crystal material having faster response characteristics with a lower driving voltage. Requirements

are becoming further differentiated, such as a liquid crystal materials with lower possibilities of display defects, in order to improve the production yield, and liquid crystal materials capable of providing greater pre-tilt angles.

[0008]

As a liquid crystal material capable of providing a brighter display and higher contrast without the need for a polarizer plate or an alignment treatment process, liquid crystal display elements made by dispersing liquid crystal droplets in a polymer are disclosed in Published Japanese Translation No. Sho 58-501631 of the PCT Application, U.S. Patent No.4,435,047, Published Japanese Translation No. Sho 61-502128 of the PCT Application, Japanese Unexamined Patent Application, First Publication No. Sho 62-2231, and the like. (These liquid crystal display elements will be hereinafter collectively referred to as PDLCs.) These elements have such problems that it is necessary to optimize the birefringences of the liquid crystal materials and the birefringence of the polymer, and a high voltage is required to achieve sufficient transparency. On the other hand, in order to achieve low-voltage drive capability, high contrast and multiplexing drive, U.S. Patent No. 5,304,323 and Japanese Unexamined Patent Application, First Publication No. Hei 1-198725 disclose liquid crystal display elements having such a structure that the liquid crystal material forms a continuous layer and a polymer is distributed in the continuous layer in a three-dimensional network structure. (This liquid crystal

display element will be hereinafter referred to as a PN-LCD.)

For a liquid crystal material used for the purpose described above, European Patent Publication No. 359,146 discloses a method for optimizing the birefringent index and dielectric constant anisotropy of the liquid crystal material, Japanese Unexamined Patent Application, First Publication No. Hei 6-222320 discloses a technology to set a particular elastic constant of the liquid crystal material, and Japanese Unexamined Patent Application, First Publication No. Hei 5-339573 discloses the use of a fluoro compound. However, there remain problems in the voltage holding ratio with high resistance, low driving voltage, contrast ratio related to the intensity of light scattering, response speed, temperature characteristics and other properties, and development efforts are still being made.

[0009]

As described above, liquid crystal display elements are still required to have a capability to display with higher resolution and higher density, faster response speed for a driving voltage and ambient temperature, lower driving voltage with high chemical and electrical stability, higher tone display characteristics, and higher contrast for the operating temperature and view angle. For this purpose, research and development activities are underway to find liquid crystal materials that have nematic characteristics over a wide temperature range, maintain the nematic phase for a long period of time while being stored at a low temperatures, with

a lower viscosity that allows improved response characteristics and capable of operating at a desired driving voltage, particularly at a lower driving voltage. Efforts for improvements are also focused on the design and temperature dependence of the birefringent index, dielectric constant anisotropy, elastic constant, light wavelength dependence of the birefringent index, and frequency dependency of the dielectric constant anisotropy in correspondence to the duty number.

[0010]

As compounds related to the general formulas (I-1) to (I-3) of the present invention, compounds of the following general formulas (a-1) to (a-8) are described. For example, compounds of the general formula (a-1) are disclosed in Helvetica Chimica Acta, vol. 68, p. 1406 (1985), Mol. Cryst. Liq. Cryst., vol. 206, p. 187 (1991), and Liq. Cryst., vol.15, p.123 (1993); compounds of the general formula (a-2) are disclosed in Published Japanese Translation No. Hei 4-504571 (1992) of the PCT Application, U.S. Patent No. 5,252,253 (1993); compounds of the general formula (a-3) are disclosed in Mol. Cryst. Liq. Cryst., vol. 206, p. 187 (1991), Liq. Cryst., vol. 15, p. 123 (1993), Japanese Unexamined Patent Application, First Publication No. Hei 1-160924 (1989), German Patent Application No. 3837208A (1998) and U.S. Patent No. 5,084,204 (1992); compounds of the general formula (a-4) are disclosed in Mol. Cryst. Liq. Cryst., vol. 37, p. 249 (1976) and U.S. Patent No. 3,925,237 (1975); compounds of the

general formula (a-5) are disclosed in Mol. Cryst. Liq. Cryst., vol. 53, p. 147 (1979) and Japanese Unexamined Patent Application, First Publication No. Sho 53-22882 (1978); compounds of the general formula (a-6) are disclosed in Japanese Unexamined Patent Application, First Publication No. Hei 54-157541 (1979), U.S. Patent No. 4,261,651 (1981) and GB Patent No. 2023136B (1979); compounds of the general formula (a-7) are disclosed in Mol. Cryst. Liq. Cryst., vol. 37, p. 249 (1976); and compounds of the general formula (a-8) are disclosed in GB Patent Application No. 2271771A (1994).

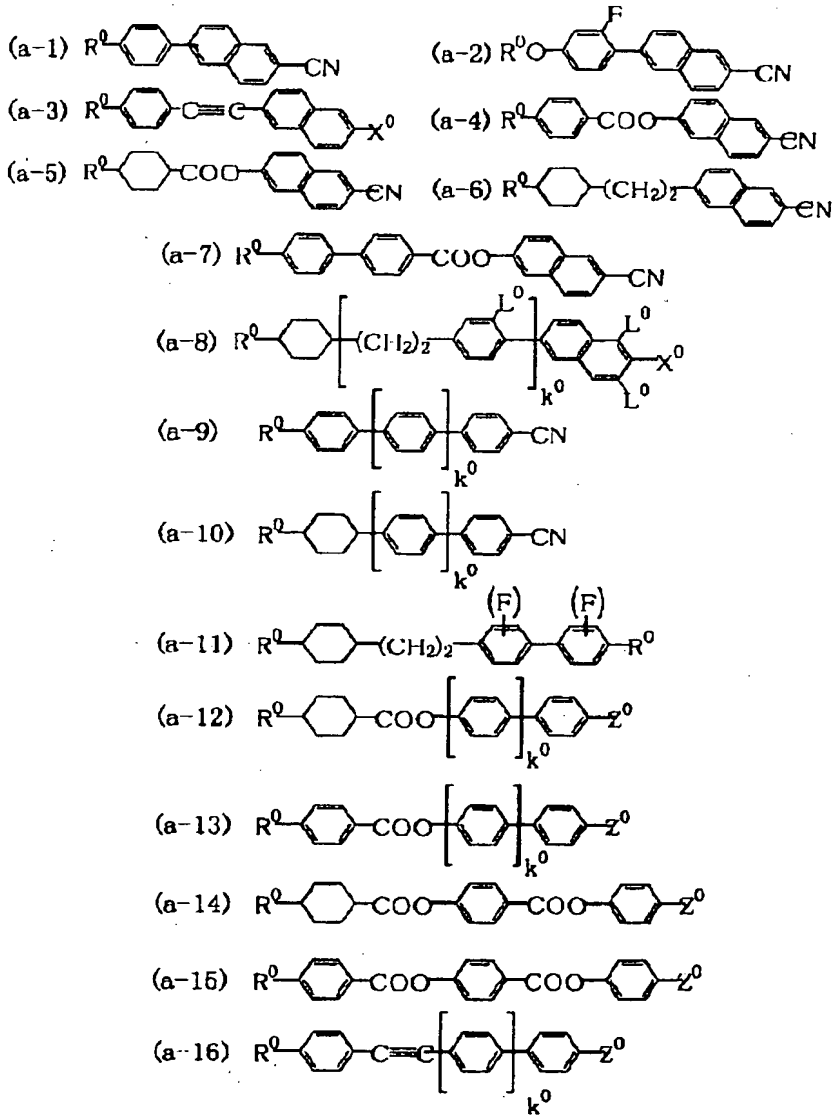
[0011]

However, patents with respect to Japanese Unexamined Patent Application, First Publication No. Hei 1-160924 (1989), German Patent Application No. 3837208A (1998), and GB Patent Application No. 2271771A (1994) were not completed and, therefore, techniques related to compounds of the general formulas (a-1) to (a-8) are scarcely known. Concerning detailed description of the compounds, although the phase transition temperatures of the compounds of the general formulas (a-1) to (a-5) and (a-7) as well as the birefringent index, dielectric constant anisotropy or transition enthalpy of some of these compounds have been reported, the elastic constants and viscosities were not known. As for compositions, although combinations of compounds of the general formulas (a-1) to (a-9) with general compounds, or combinations with compounds of the general formulas (a-9) to (a-11), or combinations with compounds of the general formulas

(a-9) to (a-16) are described, specific examples thereof are scarcely disclosed. Application examples using the liquid crystal compositions, e.g. specific examples related to liquid crystal display elements, liquid crystal display devices or the like are scarcely disclosed.

[0012]

[Chemical Formula 4]



(wherein R^0 represents an alkyl group, an alkoxy group, an alkanoyloxy group; X^0 represents CN or F; Z^0 represents R^0 or

CN; and k^0 represents 1 or 2).

[0013]

[Problems to be Solved by the Invention]

The present invention is directed to a nematic liquid crystal composition containing at least one of the compounds represented by the general formulas (I-1) to (I-3) and, more particularly, to a nematic liquid crystal composition containing one, or two or more kinds of compounds of the general formulas (I-1) to (I-3). The present invention intends to meet the requirements for the liquid crystal materials described above, or improve their properties, with a novel nematic liquid crystal composition containing compounds in which any one of W^{111} to W^{136} is substituted, or a combination of these with compounds other than the compounds of the general formulas (I-1) to (I-3), thus improving the characteristics of the liquid crystal display elements described above.

[0014]

More particularly, the present invention intends to extend the operating temperature of the liquid crystal display by making improvements in the co-solubility and in the storage at low temperature, and to remedy the reduction in driving voltage and the change in temperature, thereby to attain comparatively fast response characteristics or to improve the response characteristics for a predetermined driving voltage. Also the present invention intends to improve various display characteristics of MIM or TFT-LCDs or PDLCs by a liquid

crystal material having a desired birefringent index and to improve display characteristics of PN-LCDs or PDLCs by a liquid crystal material having a comparatively large birefringent index.

[0015]

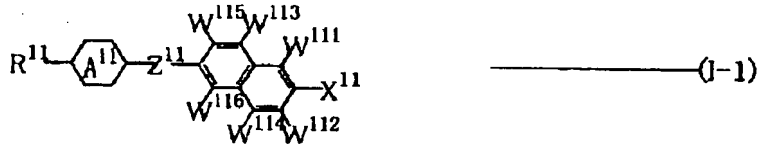
[Means for Solving the Problems]

To solve the problems described above, the present invention have found the following means for solving the problems.

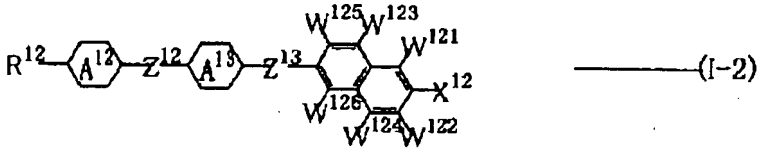
1. A nematic liquid crystal composition comprising a liquid crystal component A composed of one, or two or more kinds of compounds represented by the general formulas (I-1) to (I-3):

[0016]

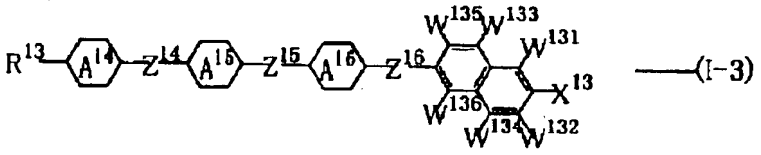
[Chemical Formula 5]



(I-1)



(I-2)



(I-3)

(wherein R^{11} to R^{13} each independently represents an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 10 carbon atoms, said alkyl or alkenyl group may have one F, CH_3 or CF_3 as a non-substituent or substituent group, or

one, or two or more CH_2 group, which are present in said alkyl or alkenyl group, each may be independently substituted with -O-, -CO- or -COO-, while O atoms do not bond with each other directly; X^{11} to X^{13} each independently represents F, Cl, CF_3, OCF_3, $OCFH_2$, NCS, or CN; W^{111} to W^{136} each independently represents H, F, Cl, CF_3, OCF_3, or CN; Z^{11} to Z^{16} each independently represents a single bond, -COO-, -OCO-, $-CH_2O-$, $-OCH_2-$, -CH=CH-, -CF=CF-, -C≡C-, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, or -N(O)=N-; and rings A^{11} to A^{16} each independently represents 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, 2,3-difluoro-1,4-phenylene, 3,5-difluoro-1,4-phenylene, pyrimidine-2,5-diyl, trans-1,4-cyclohexylene, trans-1,4-cyclohexylene, or trans-1,4-dioxane-2,5-diyl, and hydrogen atoms of said rings may be substituted with a deuterium atom if said rings represent trans-1,4-cyclohexylene); 0 to 99.9% by weight of a liquid crystal component B composed of a compound having a dielectric constant anisotropy of +2 or more as a liquid crystal component excluding the compounds of the general formulas (I-1) to (I-3); and 0 to 85% by weight of a liquid crystal component C composed of a compound having a dielectric constant anisotropy within a range from -10 to +2; the sum total of said liquid crystal component B and said liquid crystal component C being within a range from 0 to 99.9% by weight.

2. A nematic liquid crystal composition described in 1,

wherein said liquid crystal component A contains one, two or more kinds of compounds selected from compounds represented by the above general formula (I-1) or (I-2), the content of said compounds being within a range from 5 to 100% by weight in said liquid crystal component A.

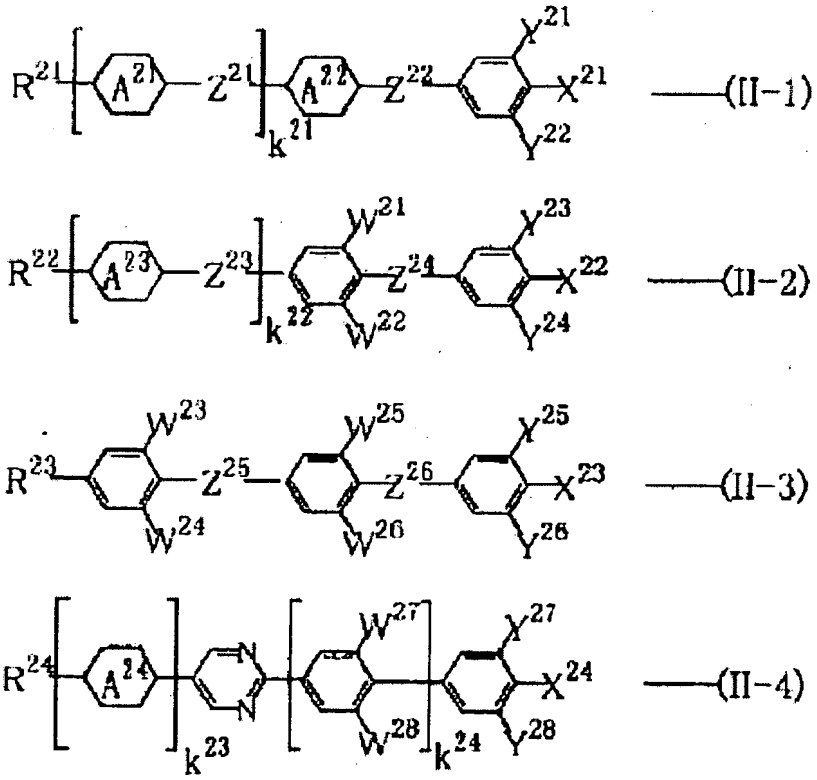
3. A nematic liquid crystal composition described in 1, wherein said liquid crystal component A contains one, two or more kinds of compounds selected from compounds represented by the above general formulas (I-1) and (I-2), the content of said compounds being within a range from 5 to 100% by weight in said liquid crystal component A.

4. A nematic liquid crystal composition described in 1, 2 or 3, wherein said liquid crystal component A contains one, or two or more kinds of compounds selected from compounds in which R^{11} to R^{13} each independently represents an alkyl or alkenyl group having 2 to 7 carbon atoms in the general formulas (I-1) to (I-3), compounds in which X^{11} to X^{13} each independently represents F, Cl, CF_3, OCF_3, OCF_2H or CN in the general formulas (I-1) to (I-3), compounds in which at least one of W^{111} to W^{113}, W^{121} to W^{123} and W^{131} to W^{133} is substituted with F in the general formulas (I-1) to (I-3), compounds in which Z^{11}, Z^{13} and Z^{16} each independently represents a single bond, $-(CH_2)_2-$, -COO- or -C≡C- in the general formulas (I-1) to (I-3), and compounds in which rings A^{11}, A^{13} and A^{16} each independently represents trans-1,4-cyclohexylene, 1,4-phenylene, 3-fluoro-1,4-phenylene or 3,5-difluoro-1,4-phenylene in the general formulas (I-1) to (I-3).

5. A nematic liquid crystal composition described in 1, 2, 3 or 4, wherein said liquid crystal component B comprises one, or two or more kinds of compounds represented by the general formulas (II-1) to (II-4):

[0017]

[Chemical Formula 6]



(II-1)

(II-2)

(II-3)

(II-4)

(wherein R^{21} to R^{24} each independently represents an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 10 carbon atoms, said alkyl or alkenyl group can have one F, CH_3 or CF_3 as a non-substituent or substituent group, or one, or two or more CH_2 groups, which are present in said alkyl or alkenyl group, each may be independently substituted with -O-, -CO- or -COO-, while O atoms do not bond with each

other directly; X^{21} to X^{24} each independently represents F, Cl, CF_3, OCF_3, OCF_2H, NCS or CN; Y^{21} to Y^{28} each independently represents H, F, Cl or OCF_3; W^{21} to W^{28} each independently represents H, F or Cl; Z^{21} to Z^{26} each independently represents a single

bond, -COO-, -OCO-, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, -CH=CH-$(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, or -N(O)=N-, and also Z^{21}, Z^{24}, Z^{25} and Z^{26} may be -CH=CH-, -CF=CF- or $-C\equiv C-$; rings A^{21} to A^{24} each independently represents trans-1,4-cyclohexylene, trans-1,4-cyclohexenylene or trans-1,4-dioxane-2,5-diyl, and also the ring A^{24} may be 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene or 3,5-difluoro-1,4-phenylene, and hydrogen atoms of said ring may be substituted with a deuterium atom if said ring represents trans-1,4-cyclohexylene; k^{21} to k^{24} each independently represents 0 or 1, and $K^{23}+k^{24}$ = 0 or 1).

6. A nematic liquid crystal composition described in 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compounds in which R^{21} to R^{24} each independently represents an alkenyl group having 2 to 5 carbon atoms in the general formulas (II-1) to (II-4); compounds in which X^{21} to X^{24} each independently represents F, Cl or $-OCF_3$ in the general formulas (II-1) to (II-4); compound in which Z^{22} is $-(CH_2)_2-$ or $-(CH_2)_4-$ in the general formula (II-1); compound in which k^{21} is 1 in the general formula (II-1); compound in which at least one of Y^{23}, Y^{24}, W^{21} and W^{22} is F in the general formula (II-2), compound in which k^{22} is 1 and Z^{24}

is -C≡C- in the general formula (II-2), compound in which Z^{23} represents a single bond or $-(CH_2)_2-$ and Z^{24} is -COO- in the general formula (II-2); compound in which at least one of Y^{25}, Y^{26} and W^{23} to W^{26} is F in the general formula (II-3), compound in which Z^{26} represent -C≡C- in the general formula (II-3); compound in which Z^{25} represents a single bond or -C≡C- and Z^{26} is -COO- in the general formula (II-3); compound represented by the general formula (II-4); and compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said ring are substituted with a deuterium atom in the general formulas (II-1) and (II-2).

7. A nematic liquid crystal composition described in 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compound in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 0 and X^{21} is -CN in the general formula (II-1); compound in which k^{21} is 1, X^{21} is F or -CN, and Y^{21} and Y^{22} represent H or F in the general formula (II-1); compound in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 0, X^{22} is -CN, and Y^{23}, Y^{24}, W^{21} and W^{22} each independently represents H or F in the general formula (II-2); compound in which k^{22} is 1, Z^{23} is a single bond, $-(CH_2)_2-$ or -COO-, Z^{24} is a single bond, -COO- or -C≡C-, X^{22} is F or -CN, and Y^{23}, Y^{24}, W^{21} and W^{22} each independently represents H or F in the general formula (II-2); compound in which R^{23} is an alkyl or alkenyl group having 2 to 5 carbon atoms, at least one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO- or -

C≡C- in the general formula (II-3); compound in which Y^{25}, Y^{26} and W^{23} to W^{26} each independently represents H or F in the general formula (II-3); compound in which R^{24} is an alkyl or alkenyl group having 2 to 7 carbon atoms and $k^{23}+k^{24}$ is 0 F in the general formula (II-4); and compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in the general formulas (II-1) and (II-2), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component B.

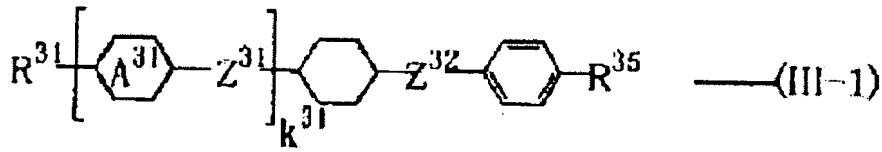
8. A nematic liquid crystal composition described in 5, wherein said liquid crystal component B contains one, or two or more kinds of compounds selected from compound in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 1, one of Z^{21} and Z^{22} is a single bond and other one is a single bond, -COO-, $-(CH_2)_2-$ or $-(CH_2)_4$, X^{21} is F, Cl, CF_3, OCF_3 or OCF_2H, and one or two Y^{21} and Y^{22} represent F in the general formula (II-1); compound in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 1, Z^{23} is $-(CH_2)_2-$ or -COO-, Z^{24} is a single bond, -COO- or -C≡C-, X^{22} is F, Cl, CF_3, OCF_3 or OCF_2H, one or two Y^{23} and Y^{24} represent F, and W^{21} and W^{22} represent H or F in the general formula (II-2); compound in which R^{23} is an alkyl or alkenyl having 2 to 5 carbon atoms, one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO- or -C≡C-, X^{23} is F, one or two Y^{25} and Y^{26} represent F, and W^{23} to W^{26} each independently represents H or one or more of them represent F in the general formula (II-3); and

compounds in which rings A^{21} to A^{23} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in the general formulas (II-1) and (II-2), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component B.

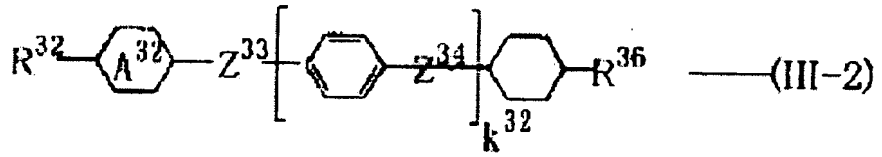
9. A nematic liquid crystal composition described in any one of 1 to 8, wherein said liquid crystal component C comprises one, or two or more kinds of compounds represented by the general formulas (III-1) to (III-4):

[0018]

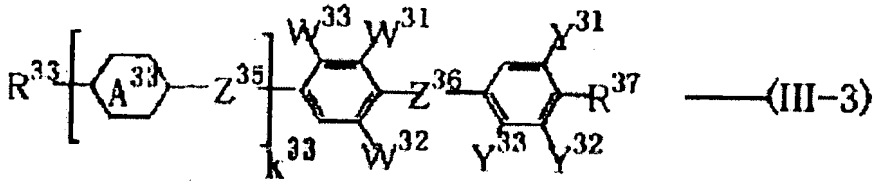
[Chemical Formula 7]



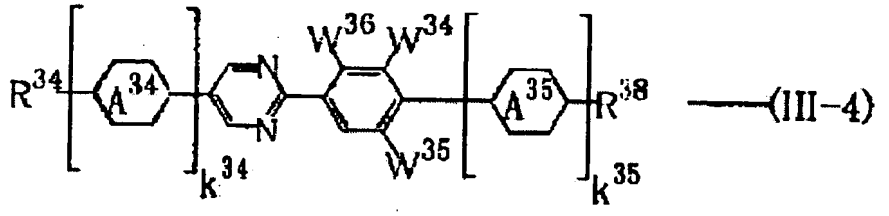
(III-1)



(III-2)



(III-3)



(III-4)

(wherein R^{31} to R^{38} each independently represents an alkyl or

alkoxy group having 1 to 7 carbon atoms, or an alkenyl or alkenyloxy group having 2 to 7 carbon atoms, said alkyl group, said alkoxy group, said alkenyl group or said alkenyloxy group may have one F, CH_3 or CF_3 as a non-substituent or substituent group, or one, or two or more CH_2 groups, which are present in said alkyl or alkenyl group, each may be independently substituted with -O-, -CO- or -COO-, while O atoms do not bond with each other directly; Y^{31} to Y^{36} each independently represents H or F, and also Y^{33} and Y^{36} may represent $-CH_3$; W^{31} to W^{39} each independently represents H, F or Cl; Z^{31} to Z^{36} each independently represents a single bond, -COO-, -OCO-, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, -CH=CH-$(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, or -N(O)=N-, and also Z^{31} and Z^{34} to Z^{36} may be -CH=CH-, -CF=CF- or $-C\equiv C-$; rings A^{31} to A^{35} each independently represents trans-1,4-cyclohexylene, trans-1,4-cyclohexenylene or trans-1,4-dioxane-2,5-diyl, and also rings A^{31} and A^{33} to A^{35} may be 1,4-phenylene, 2- or 3-fluoro-1,4-phenylene, 2,3-difluoro-1,4-phenylene, 3,5-difluoro-1,4-phenylene, and hydrogen atoms of said rings may be substituted with a deuterium atom if said rings represent trans-1,4-cyclohexylene; k^{31} to k^{35} each independently represents 0 or 1, and $K^{34}+k^{35}$ = 0 or 1).

10. A nematic liquid crystal composition described in 9, wherein said liquid crystal component C contains one, two or more kinds of compounds selected from compound represented by the general formula (III-1), compound represented by the general formula (III-2) or compound represented by the general

formula (III-3), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component C.

11. A nematic liquid crystal composition described in 9, wherein said liquid crystal component C contains one, or two or more kinds of compounds selected from compounds in which R^{31} to R^{34} represent an alkenyl group having 2 to 5 carbon atoms in the general formulas (III-1) to (III-4); compounds in which R^{35} to R^{38} represent a straight-chain alkenyl or alkenyloxy group having 2 to 7 carbon atoms in the general formulas (III-1) to (III-4); compound in which k^{31} is 0 and Z^{32} is a single bond or $-(CH_2)_2-$ in the general formula (III-1); compound in which k^{31} is 1 in the general formula (III-1); compound represented by the general formula (III-2); compound in which at least one of Y^{34}, Y^{35} and W^{34} to W^{36} is F and Y^{36} is F or $-CH_3$ in the general formula (III-3); compound in which k^{33} is 0 and Z^{36} is a single bond in the general formula (III-3); compound in which k^{33} is 1, Z^{35} is a single bond, $-OCO-$, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, $-CH=N-$, $-CH=N-N=CH-$, $-N(O)=N-$, $-CH=CH-$ or $-CF=CF-$ in the general formula (III-3); compound in which Z^{35} is $-COO-$ or $-C\equiv C-$ and Z^{36} is $-OCO-$, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, $-CH=CH-(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, $-CH=N-$, $-CH=N-N=CH-$, $-N(O)=N-$, $-CH=CH-$, $-CF=CF-$ or $-C\equiv C-$ in the general formula (III-3); compound represented by the general formula (III-4); and compounds in which rings A^{31} to A^{35} represent trans-1,4-cyclohexylene and hydrogen atoms of said rings are substituted with a deuterium atom in compounds

represented by the general formulas (III-1) to (III-4).

12. A nematic liquid crystal composition described in 9, wherein said liquid crystal component C contains one, or two or more kinds of compounds selected from compound in which R^{31} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{35} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{31} is 0, and Z^{32} is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-1); compound in which k^{31} is 1, ring A^{31} is trans-1,4-cyclohexylene, one of Z^{31} and Z^{32} is a single bond and the other one is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-1); compound in which R^{32} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{36} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, ring A^{32} is trans-1,4-cyclohexylene or trans-1,4-cyclohexenylene, k^{32} is 0 and Z^{33} is a single bond, -COO- or $-(CH_2)_2-$ in the general formula (III-2); compound in which k^{32} is 1 and one of Z^{33} and Z^{34} is a single bond in the general formula (III-2); compound in which R^{33} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{37} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{33} is 0 and Z^{36} is a single bond, -C≡C- or -CH=N-N=CH- in the general formula (III-3); compound in which k^{33} is 1, Z^{35} is a single bond, $-(CH_2)_2-$, -COO- or -C≡C- and Z^{36} is a single

bond, -COO- or -C≡C- in the general formula (III-3); compound in which one of Z^{35} and Z^{36} is a single bond and the other one is a single bond or -C≡C- and at least one of W^{34} and W^{35} is F in the general formula (III-3); compound in which one of Y^{35} and Y^{36} is substituted with F and CH_3 in the general formula (III-3); and compound in which R^{34} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{38} is an alkyl or alkoxy group having 1 to 5 carbon atoms or an alkenyl or alkenyloxy group having 2 to 5 carbon atoms and $k^{34}+k^{35} = 0$ in the general formula (III-4), the content of said compounds being within a range from 10 to 100% by weight in said liquid crystal component C.

13. A nematic liquid crystal composition described in any one of 1 to 12, wherein said liquid crystal composition contains one, or two or more kinds of core-structure compounds which have four six-membered rings and a liquid crystal phase-isotropic liquid phase transition temperature of 100°C or higher.

14. A nematic liquid crystal composition described in any one of 1 to 13, wherein said liquid crystal composition has a dielectric constant anisotropy within a range from 4 to 30, a birefringent index within a range from 0.08 to 0.35, a nematic phase-isotropic liquid phase transfer temperature within a range from 50 to 180°C or higher, and a crystal phase-, smectic phase- or glass phase-nematic phase transfer temperature within a range from -200 to 0°C.

15. A nematic liquid crystal composition described in any one

of 1 to 14, wherein said liquid crystal composition contains a compound having an optically active group capable of securing an induced helical pitch within a range from 0.5 to 1000 μm.

16. An active matrix, twisted nematic or super twisted nematic liquid display device using the nematic liquid crystal composition described in 15.

17. A light scattering type liquid display device comprising a light modulation layer which contains the liquid crystal composition described in any one of 1 to 15 and a transparent solid substance.

18. A light scattering type liquid display device described in 17, wherein said liquid crystal composition formed a continuous layer in said light modulation layer and said transparent solid substance formed a uniform three-dimensional network in said continuous layer.

the heating acceleration test, resistivity after heating acceleration test, voltage holding ratio before heating acceleration test and voltage holding ratio after heating acceleration test of the liquid crystal composition were measured.

[0019]

[Embodiments of the Invention]

One example of the present invention will now be described. The definitions in the following formulas are the same as described above unless otherwise specified.

[0020]

The liquid crystal composition of the present invention

contains, as an essential component, a liquid crystal component A composed of compounds of the general formulas (I-1) to (I-3). The compounds represented by the general formulas (I-1) to (I-3) are characterized by a molecular structure having, as a partial structure, naphthalene-2,6-diyl having a polar group. The liquid crystal component A having this feature has the effects that the response characteristics are maintained because of the comparatively good nematic phase-isotropic liquid phase transition temperature, or that the driving voltage is reduced without deteriorating the response characteristics, when mixing the liquid crystal component A with a liquid crystal compound or composition, and has excellent characteristics which are not found in a conventional liquid crystal compounds having a reduced driving voltage. The present inventors have found that this effect can be exerted when the liquid crystal composition contains a liquid crystal component A composed of compounds of the general formulas (I-1) to (I-3), 0 to 99.9% by weight of a liquid crystal component B composed of a compound having a dielectric constant anisotropy of +2 or more and 0 to 85% by weight of a liquid crystal component C composed of a compound having a dielectric constant anisotropy within a range from -10 to +2, the sum total of the liquid crystal component B and the liquid crystal component C being within a range from 0 to 99.9% by weight. The liquid crystal component A noticeably reduces the solid phase- or smectic phase-nematic phase transition temperature and lengthens the storage time at low

temperature, thereby making it possible to widen the display temperature range, when mixing the liquid crystal component A with liquid crystal materials of the liquid crystal component B and the liquid crystal component C.

[0021]

The present inventors have found it preferable in order to obtain the effects of the present invention that the liquid crystal component A contains one, or two or more kinds of compounds selected from compounds represented by the general formula (I-1) or (I-2) or contains compounds represented by the general formulas (I-1) and (I-2) in combination, the content of the compounds being within a range from 5 to 100% by weight.

[0022]

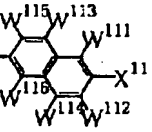
In the present invention, if a nematic liquid crystal composition does not contain the liquid crystal components B and C and is only composed of the liquid crystal component A, the liquid crystal component A contains two or more kinds, preferably five or more kinds of compound selected from compounds represented by the general formulas (I-1) to (I-3).

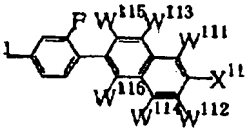
[0023]

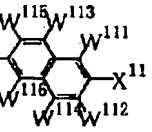
In view of the above, more preferred embodiments of basic structures of the compounds represented by the general formulas (I-1) to (I-3) are compounds represented by the general formulas (I-1a) to (I-3ab).

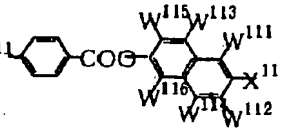
[0024]

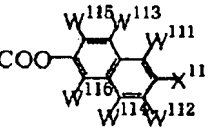
[Chemical Formula 8]

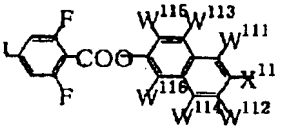
(I-1a) 

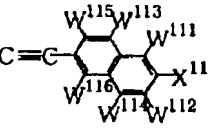
(I-1b) 

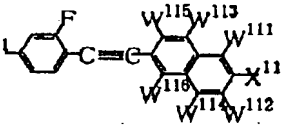
(I-1c) 

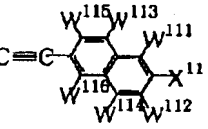
(I-1d) 

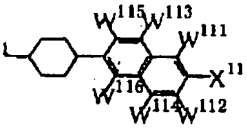
(I-1e) 

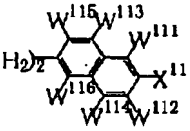
(I-1f) 

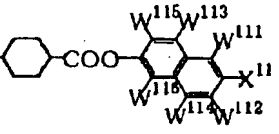
(I-1g) 

(I-1h) 

(I-1i) 

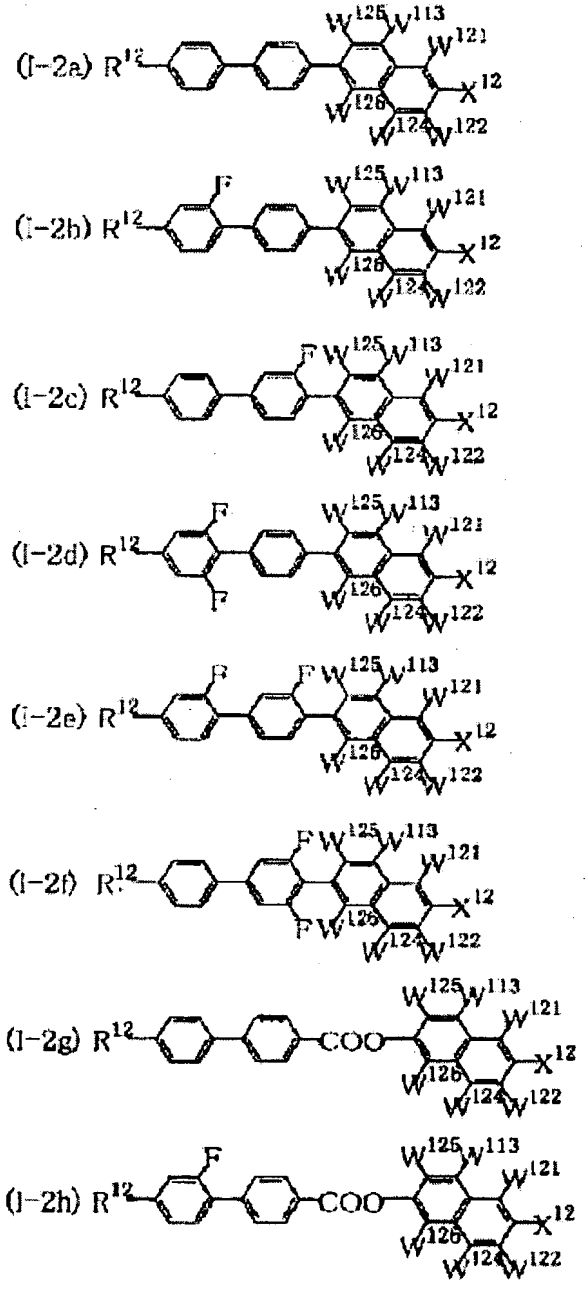
(I-1j) 

(I-1k) 

(I-1l) 

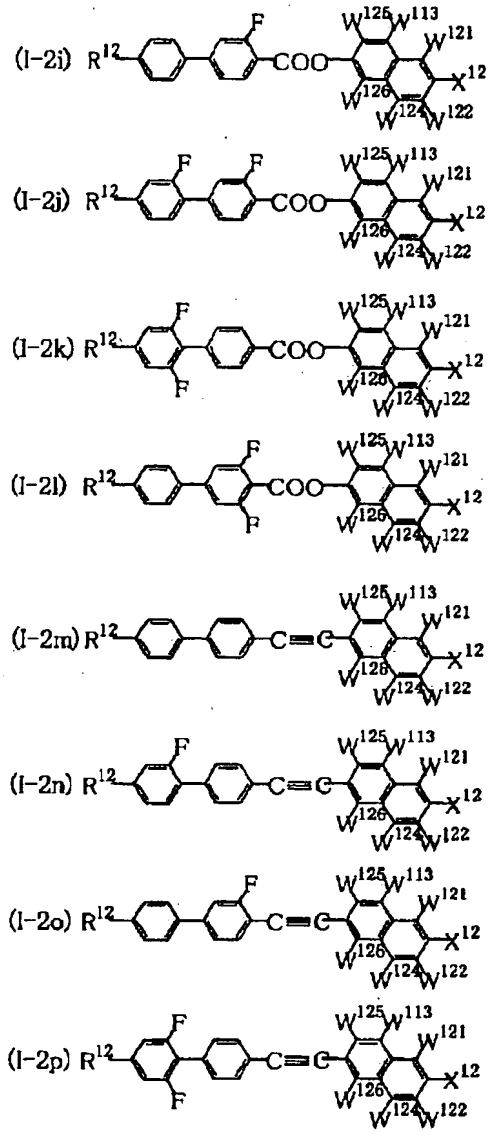
[0025]

[Chemical Formula 9]



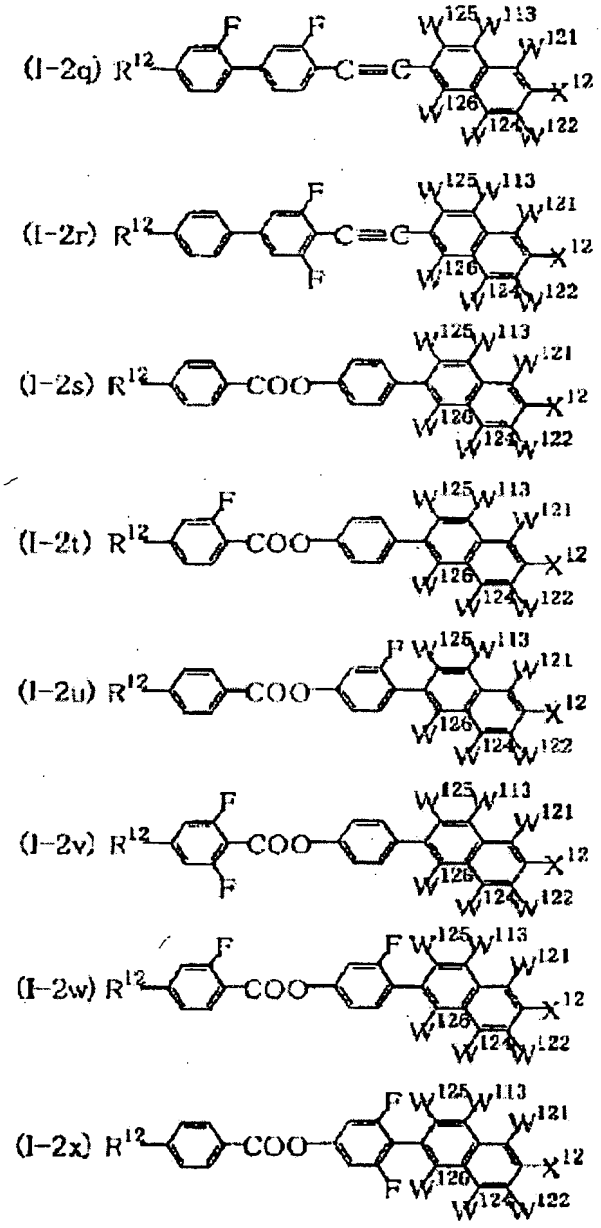
[0026]

[Chemical Formula 10]



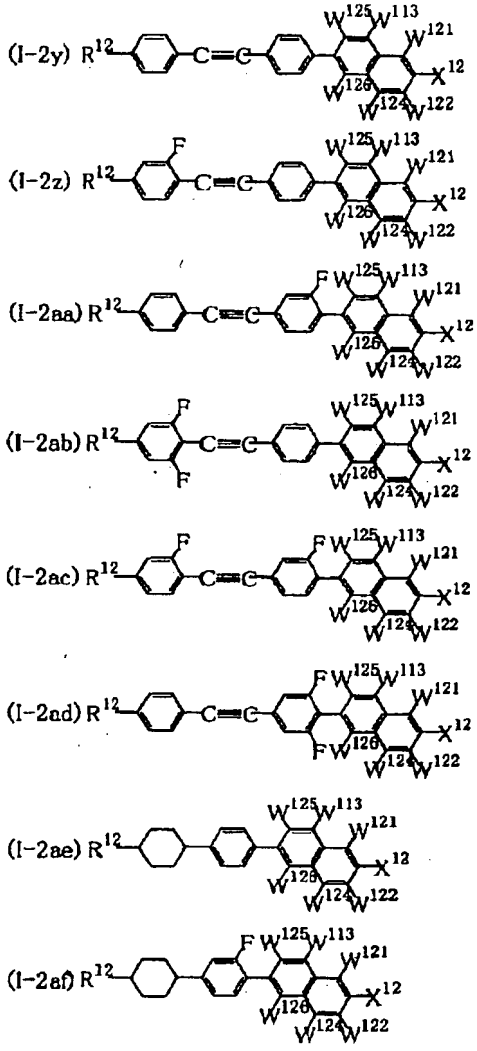
[0027]

[Chemical Formula 11]



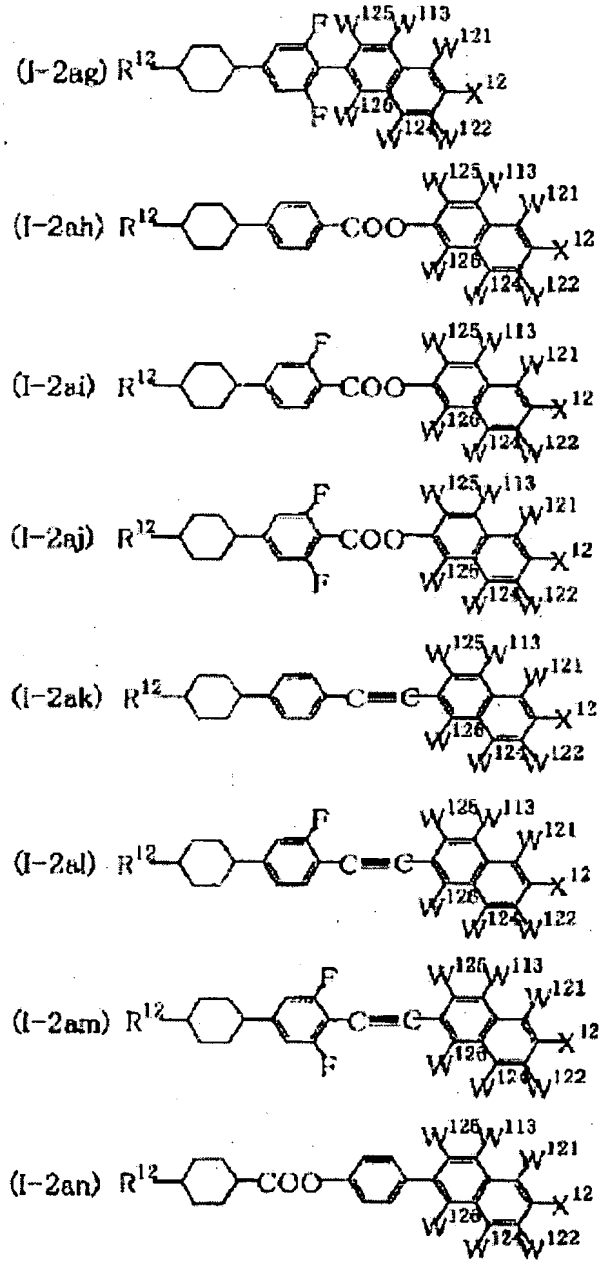
[0028]

[Chemical Formula 12]



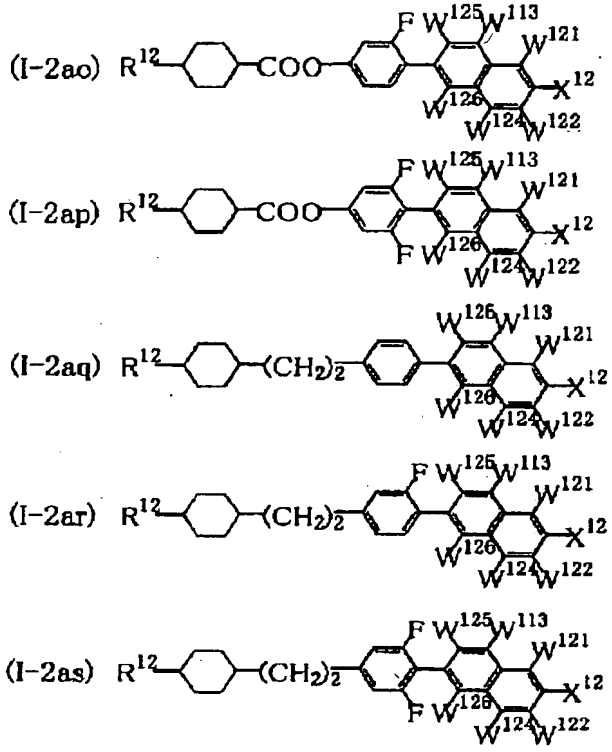
[0029]

[Chemical Formula 13]



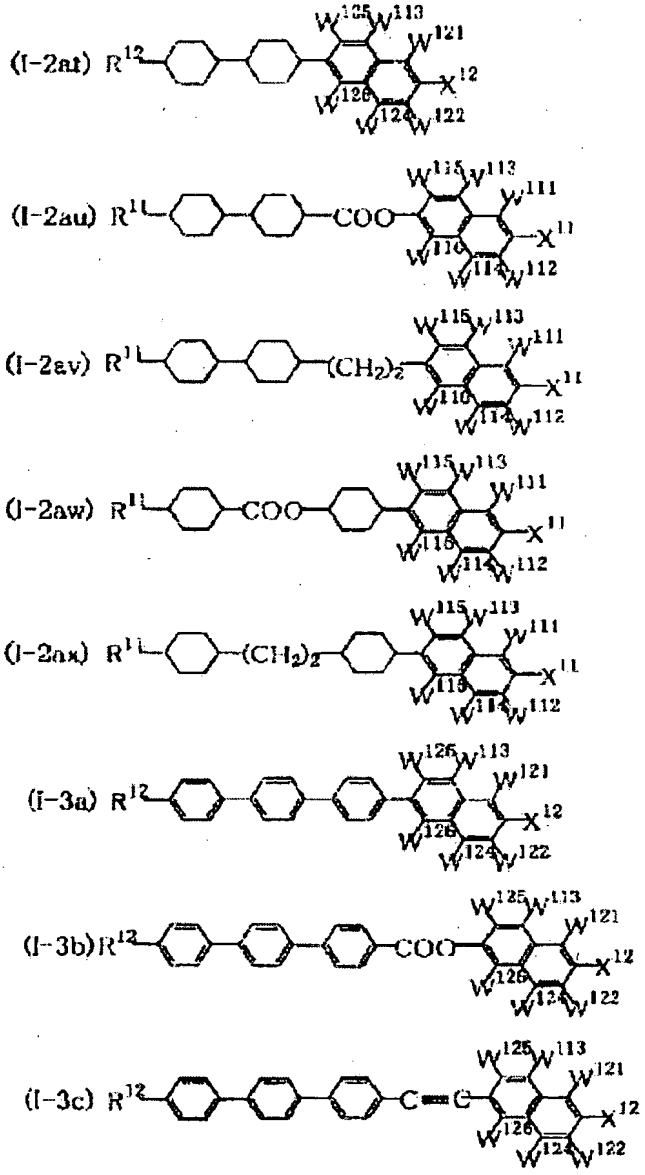
[0030]

[Chemical Formula 14]



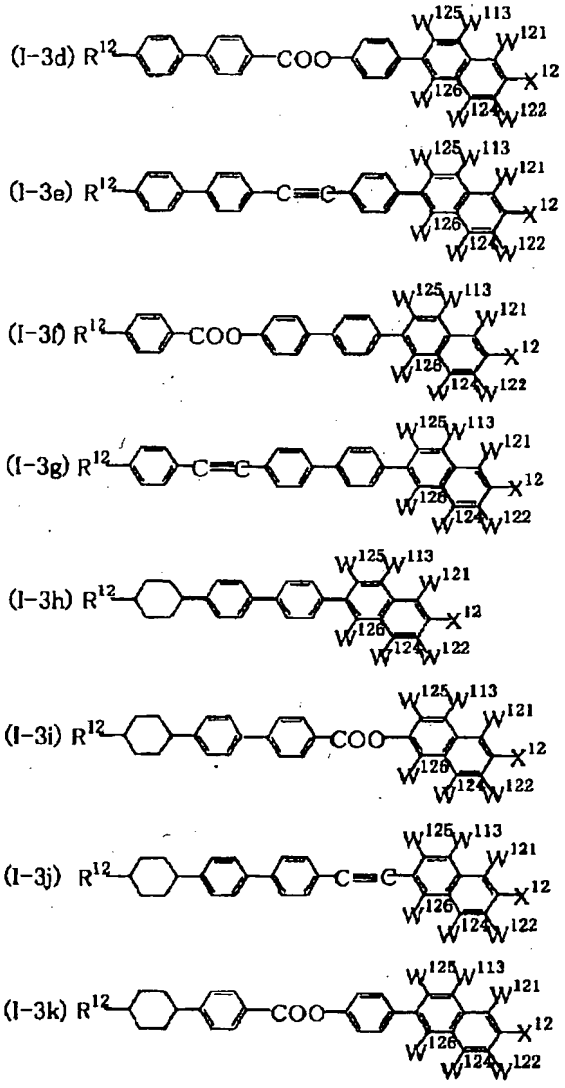
[0031]

[Chemical Formula 15]



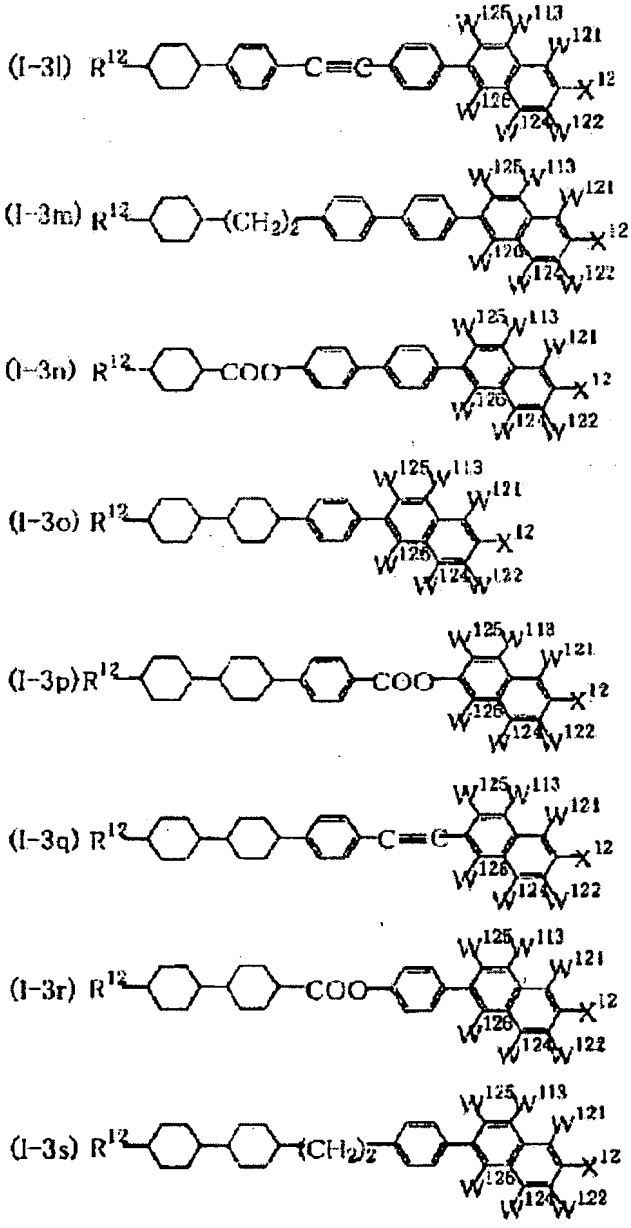
[0032]

[Chemical Formula 16]



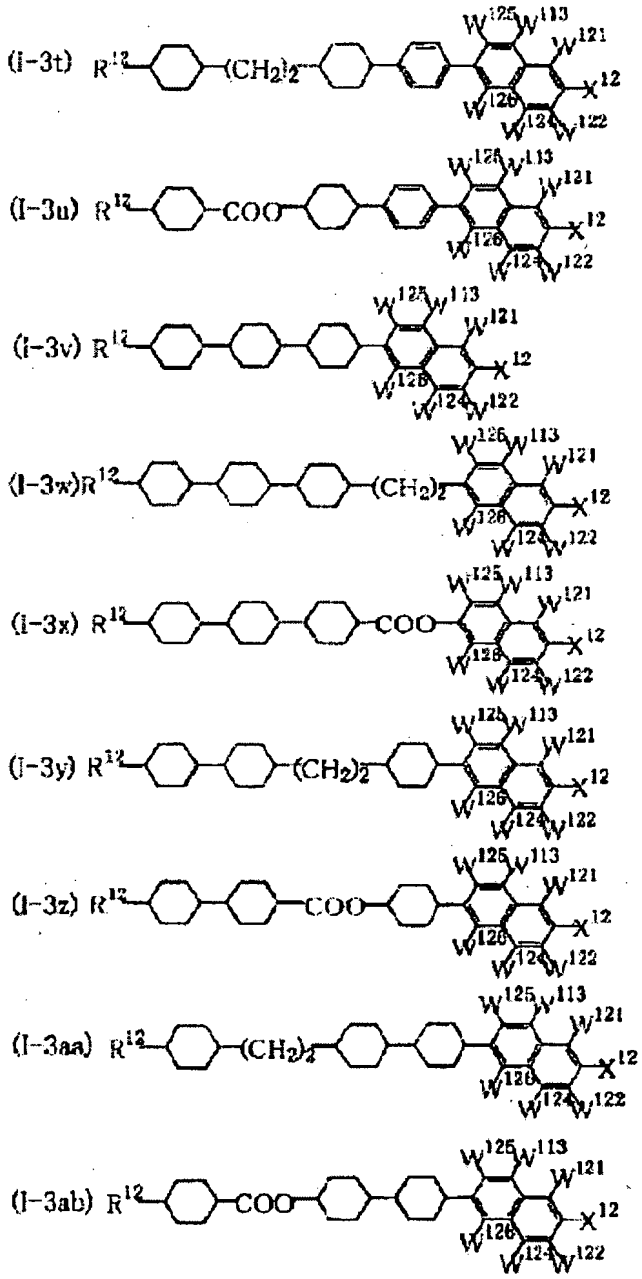
[0033]

[Chemical Formula 17]



[0034]

[Chemical Formula 18]



More preferred embodiments of the formulas (I-41) to (I-43):

[0035]

[Chemical Formula 19]

(I-41) R^{11}— (I-42) R^{12}— (I-43) R^{13}—

in side chain groups R^{11} to R^{13} include compounds represented by the following general formulas (I-4a) to (I-4bc).

[0036]

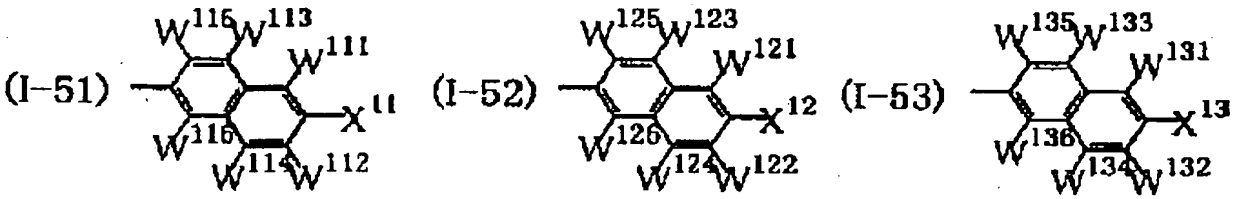
[Chemical Formula 20]

(I-4a) C_2H_5—	(I-4g) C_2H_5O—	(I-4m) C_2H_5COO—
(I-4b) C_3H_7—	(I-4h) C_3H_7O—	(I-4n) C_3H_7COO—
(I-4c) C_4H_9—	(I-4i) C_4H_9O—	(I-4o) C_4H_9COO—
(I-4d) C_5H_{11}—	(I-4j) $C_5H_{11}O$—	(I-4p) $C_5H_{11}COO$—
(I-4e) C_6H_{13}—	(I-4k) $C_6H_{13}O$—	(I-4q) $C_6H_{13}COO$—
(I-4f) C_7H_{15}—	(I-4l) $C_7H_{15}O$—	(I-4r) $C_7H_{15}COO$—
(I-4s) CH_3OCH_2—	(I-4x) $C_2H_5OCH_2$—	(I-4ac) $C_3H_7OCH_2$—
(I-4t) $CH_3OC_2H_4$—	(I-4y) $C_2H_5OC_2H_4$—	(I-4ad) $C_3H_7OC_2H_4$—
(I-4u) $CH_3OC_3H_6$—	(I-4z) $C_2H_5OC_3H_6$—	(I-4ae) $C_3H_7OC_3H_6$—
(I-4v) $CH_3OC_4H_8$—	(I-4aa) $C_2H_5OC_4H_8$—	(I-4af) $C_3H_7OC_4H_8$—
(I-4w) $CH_3OC_5H_{10}$—	(I-4ab) $C_2H_5OC_5H_{10}$—	(I-4ag) $C_3H_7OC_5H_{10}$—
(I-4ah) CH_2=CH—	(I-4ao) CH_2=CHO—	
(I-5ai) CH_3CH=CH—	(I-4ap) CH_3CH=CHO—	
(I-4aj) C_2H_5CH=CH—	(I-4aq) C_2H_5CH=CHO—	
(I-4ak) C_3H_7CH=CH—	(I-4ar) C_3H_7CH=CHO—	
(I-4al) CH_2=CHC_2H_4—	(I-4as) CH_2=CHC_2H_4O—	
(I-4am) CH_3CH_2=CHC_2H_4—	(I-4at) CH_3CH_2=CHC_2H_4O—	
(I-4an) CH_2=CHC_2H_5CH=CH—	(I-4au) CH_2=CHC_2H_5CH=CHO—	
(I-4av) CHF=CH—	(I-4az) CHF=CHC_2H_4—	
(I-4aw) CH_2=CF—	(I-4ba) CH_2=CFC_2H_4—	
(I-4ax) CF_2=CH—	(I-4bb) CF_2=CHC_2H_4—	
(I-4ay) CHF=CF—	(I-4bc) CHF=CFC_2H_4—	

More preferred embodiments of the partial structural formulas (I-51) to (I-53):

[0037]

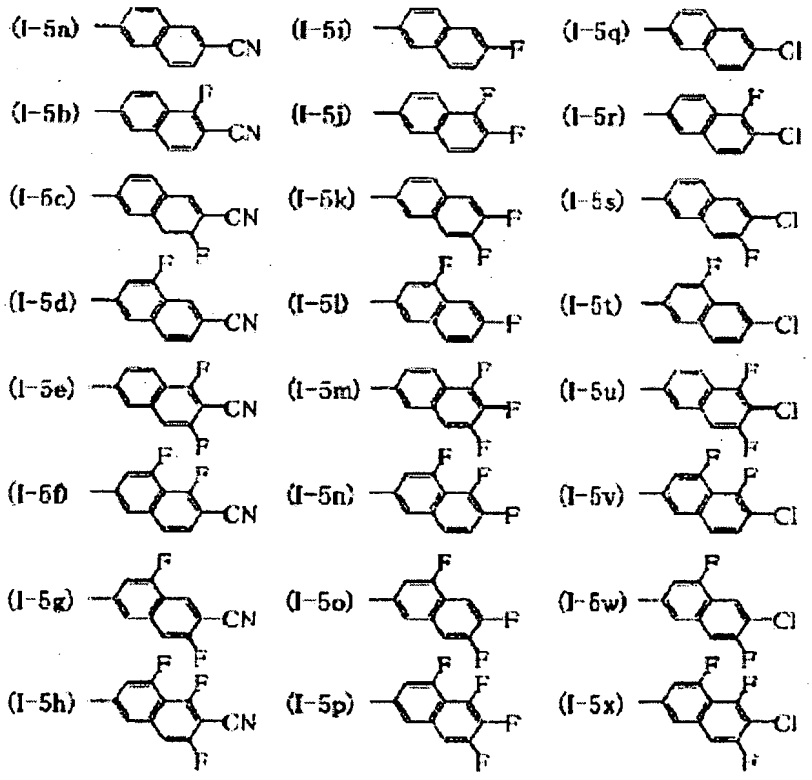
[Chemical Formula 21]



of naphthalene-2,6-diyl having a polar group include compounds represented by the following general formulas (I-5a) to (I-5av).

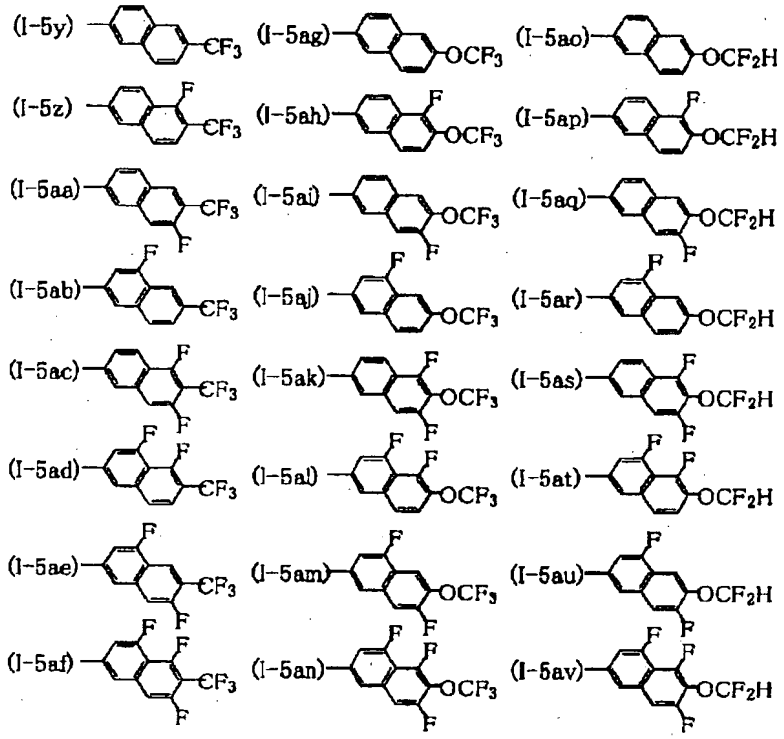
[0038]

[Chemical Formula 22]



[0039]

[Chemical Formula 23]



The respective compounds are used after sufficient purification by removing impurities using a method such as distillation, column purification, recrystallization or the like.

[0040]

In more detail, if a general liquid crystal composition is prepared, the following compounds are preferably used as the liquid crystal component A, thereby making it possible to obtain the effects of the present invention.

[0041]

(I-i): Compounds in which R^{11} to R^{13} represent an alkyl or alkenyl group having 2 to 7 carbon atoms, in the general formulas (I-1) to (I-3). Specific compounds are compounds

having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (I-4a) to (I-4af), (I-4ah) to (I-4an) and (I-4av) to (I-4bc) and the partial structures of the polar group are represented by the general formulas (I-5a) to (I-5av), and more preferably compounds having the basic structures of the general formulas (I-1a) to (I-2c), (I-2g) to (I-2i), (I-2m) to (I-2o), (I-2s) to (I-2u), (I-2y) to (I-2ax), (I-3h) and (I-3o) to (I-3aa). These compounds broaden the operating temperature range and adjust the elastic constant and its ratio K_{33}/K_{11} and K_{33}/K_{22} by an improvement in co-solubility of the liquid crystal composition and an improvement in the holding ratio at low temperatures, thus obtaining more improved electro-optical characteristics of STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0042]

(I-ii): Compounds in which X^{11} to X^{13} represent F, Cl, CF_3, OCF_3, OCF_2H, or CN, in the general formulas (I-1) to (I-3). Specific compounds are compounds having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (1-4a) to (I-4av) and the partial structures of the polar group are represented by the general formulas (I-5a) to (I-5av), preferably compounds having the basic structures of the general formulas (I-1a) to (I-2c), (I-2g) to (I-2i), (I-2m) to (I-2o), (I-2s) to (I-2u), (I-2y) to (I-2ax), (I-3h) and (I-3o) to (I-3aa), and more preferably compounds (I-5i) to (I-5av) in which X^{11} to X^{13} represent F, Cl, CF_3, OCF_3 or OCF_2H. If these compounds are used practically as a

principal component, the resulting liquid crystal is suited for use as a high-reliability STN-LCD as well as an active TFT-LCD, STN-LCD, PDLC and PN-LCD, and is superior in reduction in driving voltage and high voltage holding ratio. When compounds in which X^{11} to X^{13} represent F, Cl or CN are used practically as a principal component, it becomes possible to obtain excellent electro-optical characteristics such as driving voltage, sharpness, response characteristics and temperature characteristics of TN-LCDs, STN-LCDs, PDLCs, PN-LCDs or the like.

[0043]

(I-iii): Compounds in which at least one of W^{111} to W^{113}, W^{121} to W^{123} and W^{131} to W^{133} is substituted with F or Cl, in the general formulas (I-1) to (I-3). Specific compounds are compounds having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (I-4a) to (I-4av) and the partial structures of the polar group are represented by the general formulas (I-5b) to (I-5h), (I-5j) to (I-5p), (I-5r) to (I-5x), (I-5z) to (I-5af), (I-5ah) to (I-5an) and (I-5ap) to (I-5av), more preferably compounds in which at least W^{111}, W^{121} and W^{131} are substituted with a polar group, and particularly compounds in which they are substituted with F. These compounds broaden the operating temperature range by an improvement in co-solubility of the liquid crystal composition and an improvement in the holding ratio at low temperatures, thereby to attain comparatively fast response characteristics or to improve the response characteristics for a predetermined

driving voltage, and thus obtaining more improved electro-optical characteristics of STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0044]

(I-iv): Compounds in which Z^{11}, Z^{13} and Z^{16} is substituted with $-(CH_2)_2-$, -COO- or $-C\equiv C-$, in the general formulas (I-1) to (I-3). Specific compounds are compounds having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (I-5a) to (I-5av) and the partial structures of the polar group are represented by the general formulas (I-5a) to (I-5av), and more preferably compounds having the basic structures of the general formulas (I-1a) to (I-2c), (I-2g) to (I-2i), (I-2m) to (I-2o), (I-2s) to (I-2u), (I-2y) to (I-2ax), (I-3h), (I-3o) to (I-3aa), (I-1a) to (I-1l), (I-2y) to (I-2ax) and (I-3h) to (I-3av). These compounds broaden the operating temperature range and adjust the birefringent index, elastic constant and its ratio K_{33}/K_{11} and K_{33}/K_{22} by an improvement in co-solubility of the liquid crystal composition and an improvement in the holding ratio at low temperatures, thereby to attain comparatively fast response characteristics or to improve the response characteristics for a predetermined driving voltage, and thus obtaining more improved electro-optical characteristics of STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0045]

(I-v): Compounds in which rings A^{11}, A^{13} and A^{16} represent trans-1,4-cyclohexylene, 1,4-phenylene, 3-fluoro-1,4-

phenylene, or 3,5-difluoro-1,4-phenylene, in the general formulas (I-1) to (I-3), and specific compounds are compounds having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (I-5a) to (I-5av) and the partial structures of the polar group are represented by the general formulas (I-5a) to (I-5av), and more preferably compounds having the basic structures of the general formulas (I-1a) to (I-2c), (I-2g) to (I-2i), (I-2m) to (I-2o), (I-2s) to (I-2u), (I-2y) to (I-2ax), (I-3h), (I-3o) to (I-3aa), (I-1a) to (I-1l), (I-2y) to (I-2ax) and (I-3h) to (I-3av).

[0046]

Among compounds (I-iv) and (I-v),

(I-vi): Compounds in which Z^{11}, Z^{13} and Z^{16} represent a single bond and rings A^{11}, A^{13} and A^{16} represent 1,4-phenylene, 3-fluoro-1,4-phenylene, or 3,5-difluoro-1,4-phenylene are preferred. These compounds have medium or high birefringent index and comparatively large dielectric constant anisotropy.

[0047]

(I-vii): Compounds in which Z^{11}, Z^{13} and Z^{16} represent a single bond and rings A^{11}, A^{13} and A^{16} represent trans-1,4-cyclohexylene. These compounds have comparatively fast response characteristics because of broadened nematic phase.

[0048]

(1-viii): Compounds in which Z^{11}, Z^{13} and Z^{16} represent $-(CH_2)_2-$ and rings A^{11}, A^{13} and A^{16} represent trans-1,4-cyclohexylene. These components have good co-solubility.

[0049]

(1-ix): Compounds in which Z^{11}, Z^{13} and Z^{16} represent -COO- and rings A^{11}, A^{13} and A^{16} represent 1,4-phenylene, 3-fluoro-1,4-phenylene, or 3,5-difluoro-1,4-phenylene. These compounds have reduced driving voltage because of broadened nematic phase.

[0050]

(I-x): Compounds in which Z^{11}, Z^{13} and Z^{16} represent -C≡C- and rings A^{11}, A^{13} and A^{16} represent 1,4-phenylene, 3-fluoro-1,4-phenylene, or 3,5-difluoro-1,4-phenylene. These compounds are more preferred because they have very high or comparatively high birefringent index.

[0051]

As described above, in the present invention, a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compound shown in the sub-groups (I-i) to (I-x) is preferred.

[0052]

Although the liquid crystal composition of the present invention can contain one or more kinds of compounds represented by the general formulas (I-1) to (I-3) as the liquid crystal component A, the effects can be obtained even when composed of only one compound. Liquid crystal component A containing at least one compound represented by the general formula (I-1) or at least one compound represented by the general formula (I-2) is more preferred. The liquid crystal composition containing such a liquid crystal component A composed of a naphthalene-2,6-diyl compound having a polar

group of the present invention broadens the operating temperature range of liquid crystal display characteristics due to an improvement in co-solubility and storage at low temperature, thereby making it possible to improve a reduction in driving voltage and a change in temperature and to attain comparatively fast response characteristics for a predetermined driving voltage, thus obtaining more improved electro-optical characteristics of TN-LCDs, STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like using the liquid crystal composition as a constituent material.

[0053]

The liquid crystal composition of the present invention contains a liquid crystal component B, which contains one, or two or more kinds of compounds having a dielectric constant anisotropy of +2 or more, in addition to the liquid crystal component A. The liquid crystal compound having a dielectric constant anisotropy of +2 or more in the present invention is used in the following meaning. The liquid crystal compound is a compound which has a bar-like chemical structure, the center portion having a core structure with one to four six-membered rings, the six-membered ring positioned at both terminals in the major axis direction of the center portion having a terminal group substituted at the position corresponding to the direction of the major axis of the liquid crystal, at least one of terminal groups, which are present at both terminals, being a polar group, for example, -F, -Cl, $-NO_2$, $-CF_3$, $-OCF_3$, $-OCHF_2$, -CN, -OCN, -NCS or

the like. Consequently, it becomes possible to adjust the optical anisotropy of the liquid crystal layer to a predetermined value, thereby making it possible to electrically drive and widen the operating temperature range.

[0054]

As the liquid crystal component B, one, or two or more kinds, preferably three to forty kinds, and more preferably three to fifteen kinds of compound having a dielectric constant anisotropy of +2 or more can be used. The liquid crystal composition preferably contains the compound after appropriately selecting from compound having a dielectric constant anisotropy within a range from +2 to +8, compound having a dielectric constant anisotropy within a range from +8 to +13, compound having a dielectric constant anisotropy within a range from +14 to +18 and compound having a dielectric constant anisotropy of +18 or more. In this case, thirty kinds or less, preferably fifteen kinds or less of compounds having a dielectric constant anisotropy within a range from +2 to +13 are mixed, twenty kinds or less, preferably eight kinds or less of compounds having a dielectric constant anisotropy within a range from +14 to +18 are mixed, and fifteen kinds or less, preferably ten kinds or less of compounds having a dielectric constant anisotropy of +18 or more are mixed. Use of the liquid crystal component in the above manner exerts more preferred effects due to temperature characteristics of display characteristics. More specifically, it improves the dependence of the temperature on

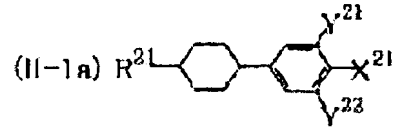
the driving voltage, contrast related to sharpness, response characteristics or the like.

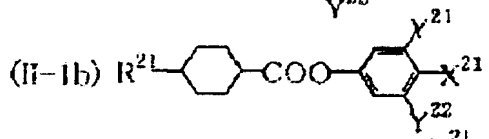
[0055]

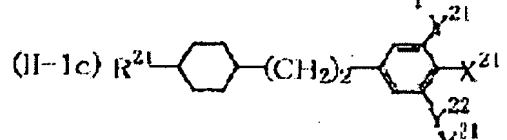
From such a point of view, more preferred mode of a basic structure in compounds represented by the general formulas (II-1) to (II-4) includes compounds represented by the general formulas (II-1a) to (II-4g).

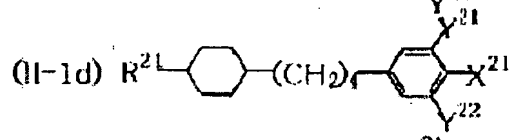
[0056]

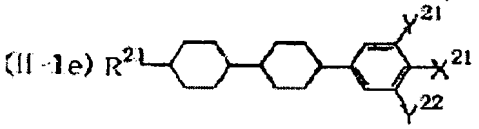
[Chemical Formula 24]

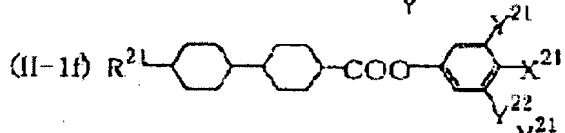
(II-1a) 

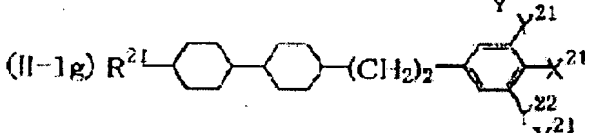
(II-1b) 

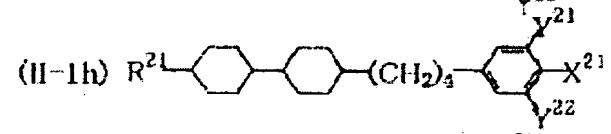
(II-1c) 

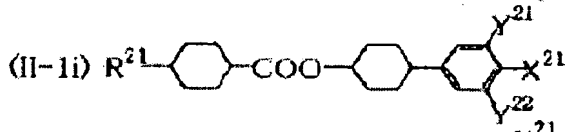
(II-1d) 

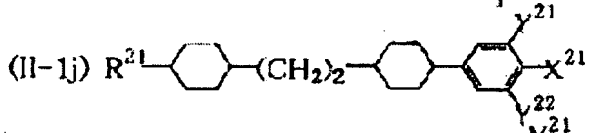
(II-1e) 

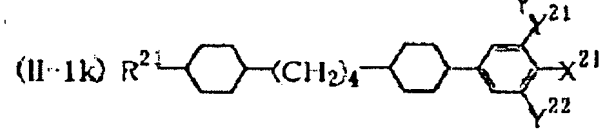
(II-1f) 

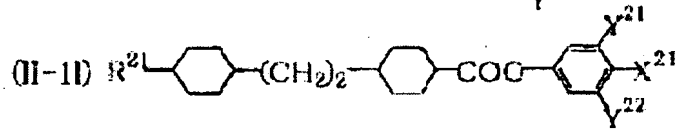
(II-1g) 

(II-1h) 

(II-1i) 

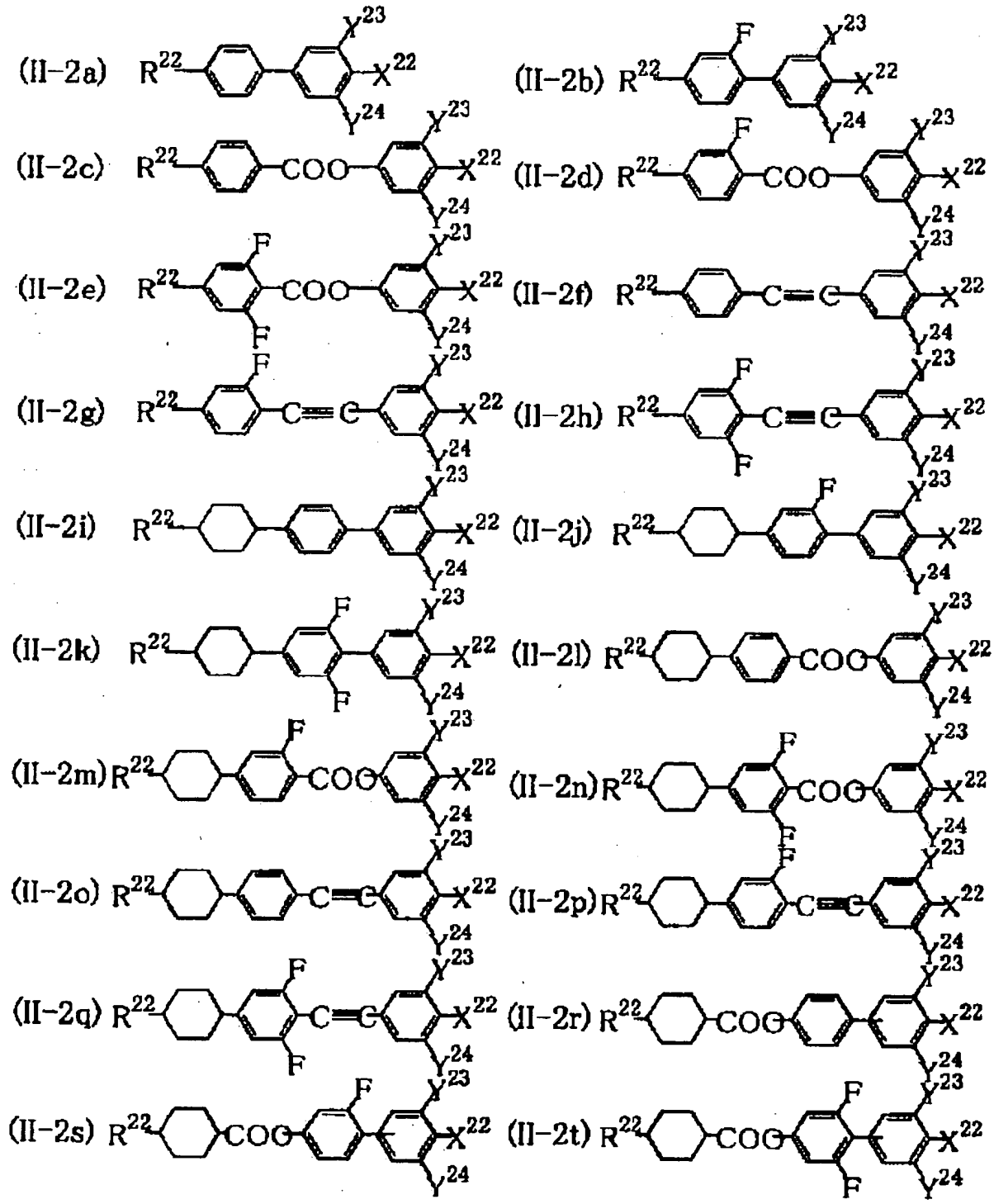
(II-1j) 

(II-1k) 

(II-1l) 

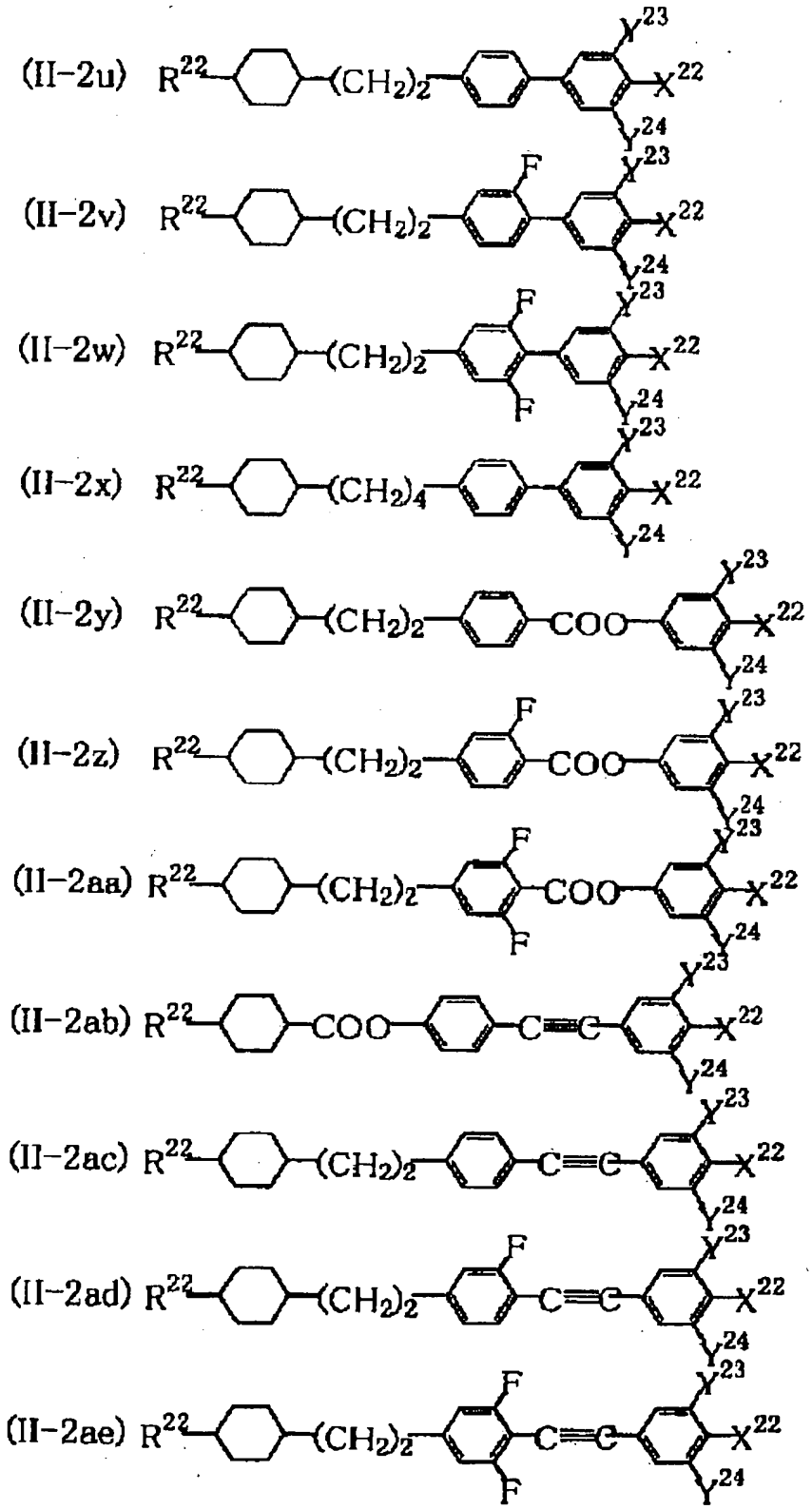
[0057]

[Chemical Formula 25]



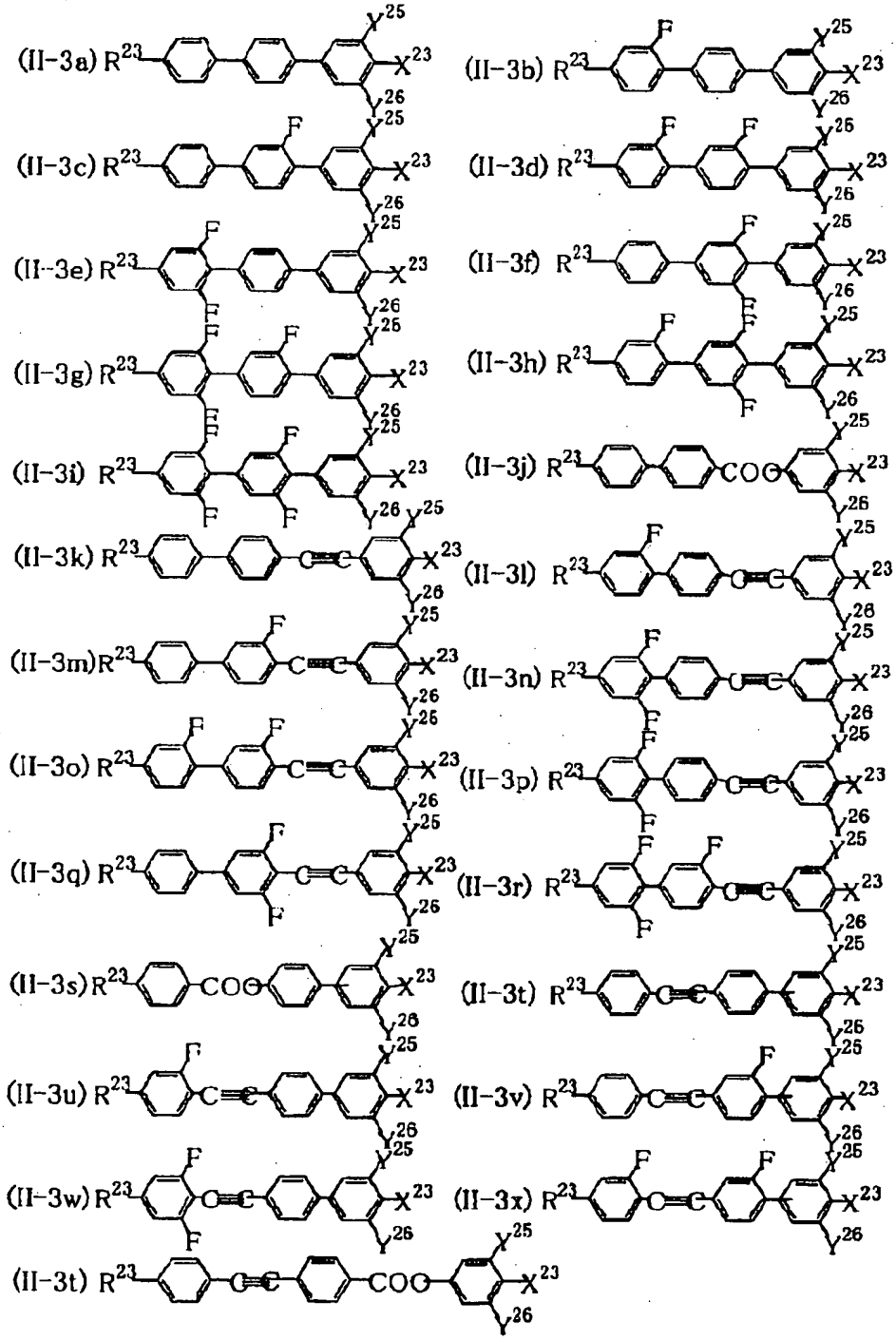
[0058]

[Chemical Formula 26]



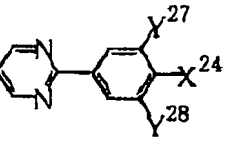
[0059]

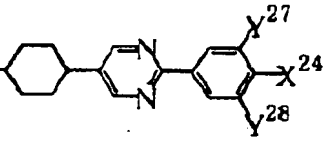
[Chemical Formula 27]

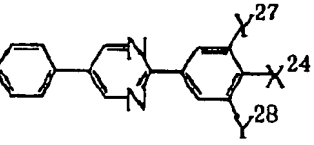


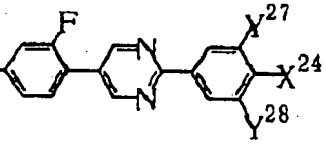
[0060]

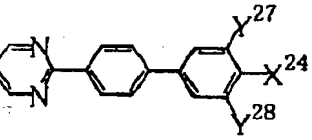
[Chemical Formula 28]

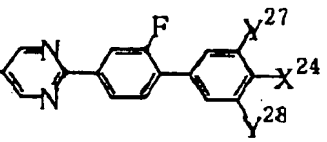
(II-4a) 

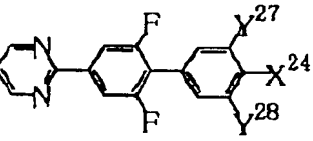
(II-4b) 

(II-4c) 

(II-4d) 

(II-4e) 

(II-4f) 

(II-4g) 

More preferred mode of the formulas (II-51) to (II-54):

[0061]

[Chemical Formula 29]

(II-51) R^{21}— (II-52) R^{22}— (II-53) R^{23}— (II-54) R^{24}—

in the side chain groups R^{21} to R^{24} includes compounds of the following general formulas (II-5a) to (II-5bc).

[0062]

[Chemical Formula 30]

(II-5a) C_2H_5—
(II-5b) C_3H_7—
(II-5c) C_4H_9—
(II-5d) C_5H_{11}—
(II-5e) C_6H_{13}—
(II-5f) C_7H_{15}—

(II-5g) C_2H_5O—
(II-5h) C_3H_7O—
(II-5i) C_4H_9O—
(II-5j) $C_5H_{11}O$—
(II-5k) $C_6H_{13}O$—
(II-5l) $C_7H_{15}O$—

(II-5m) C_2H_5COO—
(II-5n) C_3H_7COO—
(II-5o) C_4H_9COO—
(II-5p) $C_5H_{11}COO$—
(II-5q) $C_6H_{13}COO$—
(II-5r) $C_7H_{15}COO$—

(II-5s) CH_3OCH_2—
(II-5t) $CH_3OC_2H_4$—
(II-5u) $CH_3OC_3H_6$—
(II-5v) $CH_3OC_4H_8$—
(II-5w) $CH_3OC_5H_{10}$—

(II-5x) $C_2H_5OCH_2$—
(II-5y) $C_2H_5OC_2H_5$—
(II-5z) $C_2H_5OC_3H_6$—
(II-5aa) $C_2H_5OC_4H_8$—
(II-5ab) $C_2H_5OC_5H_{10}$—

(II-5ac) $C_3H_7OCH_2$—
(II-5ad) $C_3H_7OC_2H_4$—
(II-5ae) $C_3H_7OC_3H_6$—
(II-5af) $C_3H_7OC_4H_8$—
(II-5ag) $C_3H_7OC_5H_{10}$—

(II-5ah) CH_2=CH—
(II-5ai) CH_3CH=CH—
(II-5aj) C_2H_5CH=CH—
(II-5ak) C_3H_7CH=CH—
(II-5al) CH_2=CHC_2H_4—
(II-5am) CH_3CH_2=CHC_2H_4—
(II-5an) CH_2=CHC_2H_6CH=CH—

(II-5ao) CH_2=CHO—
(II-5ap) CH_3CH=CHO—
(II-5aq) C_2H_5CH=CHO—
(II-5ar) C_3H_7CH=CHO—
(II-5as) CH_2=CHC_2H_4O—
(II-5at) CH_3CH_2=CHC_2H_4O—
(II-5au) CH_2=CHC_2H_6CH=CHO—

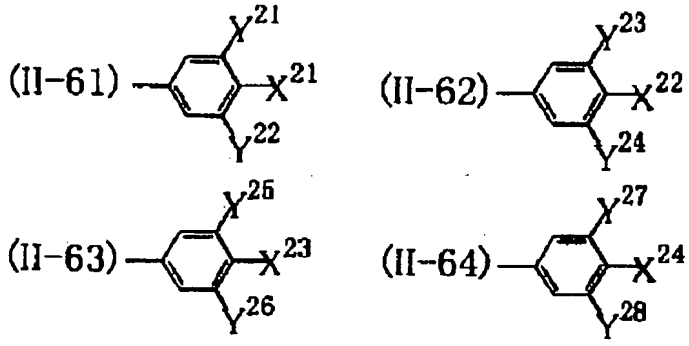
(II-5av) CHF=CH—
(II-5aw) CH_2=CF—
(II-5ax) CF_2=CH—
(II-5ay) CHF=CF—

(II-5az) CHF=CHC_2H_4—
(II-5ba) CH_2=CFC_2H_4—
(II-5bb) CF_2=CHC_2H_4—
(II-5bc) CHF=CFC_2H_4—

More preferred mode of the partial structural formulas (II-61) to (II-64):

[0063]

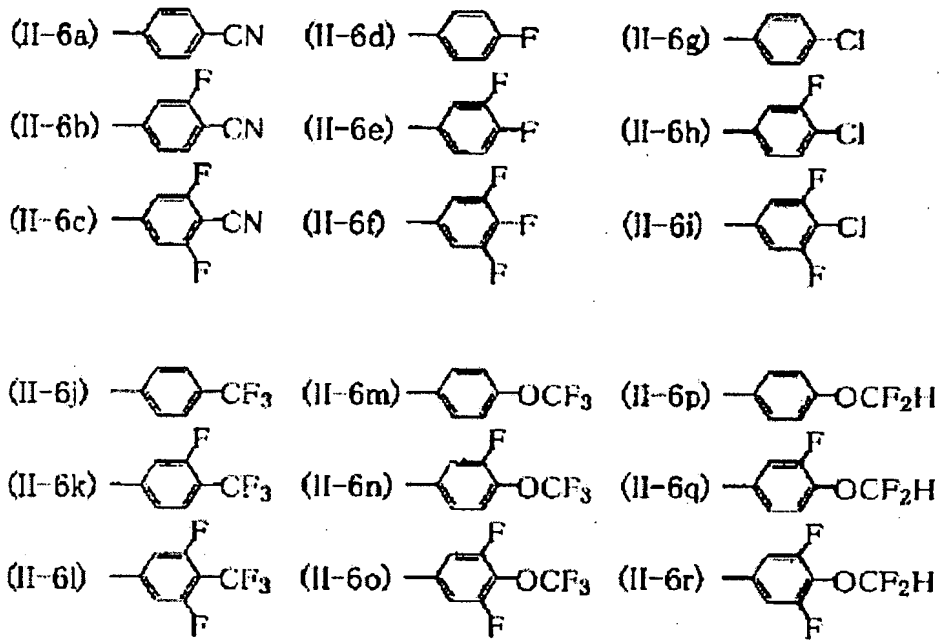
[Chemical Formula 31]



of 1,4-phenylene having a polar group includes compounds represented by the following general formulas (II-6a) to (II-6r).

[0064]

[Chemical Formula 32]



The respective compounds are used after sufficient purification by removing impurities using a means such as distillation, column purification, recrystallization or the like.

[0065]

In more detail, if a general liquid crystal composition is prepared, the following compounds are preferably used as the liquid crystal component B and the effects of the present invention can be obtained by using the liquid crystal component B with the liquid crystal component A.

[0066]

(II-ai): Compounds in which R^{21} to R^{24} represent an alkyl or alkenyl group having 2 to 5 carbon atoms, in the general

formulas (II-1) to (II-4). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-4g) in which the side chain groups are (II-5ah) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r), and preferably compounds having the basic structures of the general formulas (II-1a) to (II-1l) and (II-2i) to (II-2ae), thus obtaining more improved electro-optical characteristics of STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0067]

(II-aii): Compounds in which X^{21} to X^{24} represent F, Cl, or $-OCF_3$, in the general formulas (II-1) to (II-4). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-4g) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6d) to (II-6i) and (II-6m) to (II-6o), and preferably compounds having the basic structures of the general formulas (II-1a) to (II-1l), (II-2f) to (II-2q), (II-2u) to (II-2w) and (II-2ab) to (II-4f). If these compounds are used practically as a principal component, the resulting liquid crystal is superior in reduction in driving voltage and high voltage holding ratio of active TFT-LCD, STN-LCD, PDLC and PN-LCD. If these compounds are used in combination with compounds in which X^{21} to X^{24} represent F and CN and the both are used practically as a principal component, it becomes possible to obtain excellent electro-optical characteristics such as

driving voltage, sharpness, response characteristics and temperature characteristics of TN-LCDs, STN-LCDs, PDLCs, PN-LCDs or the like.

[0068]

(II-aiii): Compounds in which Z^{22} is $-(CH_2)_2-$ or $-(CH_2)_4-$, in the general formula (II-1). Specific compounds are compounds having the basic structures of the general formulas (II-1c), (II-1d), (II-1g) and (II-1h) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0069]

(II-aiv): Compounds in which k^{21} is 1, in the general formula (II-1). Specific compounds are compounds having the basic structures of the general formulas (II-1e) to (II-1l) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0070]

These compounds shown in (II-aiii) to (II-aiv) are suited for applications requiring low driving voltage and comparatively small birefringent index.

[0071]

(II-av): Compounds in which at least one of Y^{23}, Y^{24}, W^{21} and W^{22} is F, in the general formula (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-2a), (II-2c), (II-2f), (II-2i), (II-2l), (II-2o), (II-2r),

(II-2u), (II-2x), (II-2y), (II-2ab) and (II-2ac) in which the side chain groups are (II-5a) to (II-5bc) and the partial structure of the polar group are represented by the general formulas (II-6b), (II-6c), (II-6e), (II-6f), (II-6h), (II-6i), (II-6k), (II-6l), (II-6n), (II-6o), (II-6q) and (II-6r), or compounds having the basic structures of the general formulas (II-2b), (II-2d), (II-2e), (II-2g), (II-2h), (II-2j), (II-2k), (II-2m), (II-2n), (II-2p), (II-2q), (II-2s), (II-2t), (II-2v), (II-2w), (II-2z), (II-2aa), (II-2ad) and (II-2ae) in which the side chain groups are (I-5a) to (I-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r), which are suited for applications to reduce the driving voltage.

[0072]

(II-avi): Compounds in which k^{22} is 1 and Z^{24} is -C≡C-, in the general formula (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-2o) to (II-2q) and (II-2ab) to (II-2ae) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r), which are suited for applications requiring low driving voltage and comparatively small birefringent index.

[0073]

(II-avii): Compounds in which Z^{23} is a single bond or $-(CH_2)_2-$ and Z^{24} is -COO-, in the general formula (II-2). Specific compounds are compounds having the basic structures of the

general formulas (II-2l) to (II-2n), (II-2r) to (II-2t) and (II-2y) to (II-2aa) in which the side chain groups are (II-5a) to (II-5bc) and the partial structure of the polar group are represented by the general formulas (II-6a) to (II-6r), which are suited for applications with low driving voltage.

[0074]

(II-aviii): Compounds in which at least one of Y^{25}, Y^{25}, and W^{23} to W^{26} is F, in the general formula (II-3). Specific compounds are compounds having the basic structures of the general formulas (II-3a), (II-3j), (II-3k), (II-3s), (II-3t) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6b), (II-6c), (II-6e), (II-6f), (II-6h), (II-6i), (II-6k), (II-6l), (II-6n), (II-6o), (II-6q) and (II-6r), or compounds having the basic structures of the general formulas (II-3b) to (II-3i), (II-3l) to (II-3r) and (II-3u) to (II-3x) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r), which are suited for applications to reduce the driving voltage.

[0075]

(II-aix): Compounds in which Z^{26} is -C≡C-, in the general formula (II-3). Specific compounds are compounds having the basic structures of the general formulas (II-3k) to (II-3r) in which the side chain groups are (II-5a) to (II-5bc) and the partial structure of the polar group are represented by the general formulas (II-6a) to (II-6r), which are suited for

applications requiring low driving voltage and comparatively small birefringent index.

[0076]

(II-ax): Compounds in which Z^{25} is a single bond or -C≡C- and Z^{26} is -COO-, in the general formula (II-3). Specific compounds are compounds having the basic structures of the general formulas (II-3j) and (II-3y) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0077]

(II-axi): Compounds represented by the general formula (II-4). Specific compounds are compounds having the basic structures of the general formulas (II-4a) to (II-4g) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0078]

(II-axii): Compounds in which rings A^{21} to A^{24} represent trans-1,4-cyclohexylene and at least one of hydrogen atoms of this ring is substituted with a deuterium atom, in the general formulas (II-1) and (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-1l) and (II-2i) to (II-2ae) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0079]

As described above, in the present invention, a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compounds shown in these sub-groups (II-ai) to (II-axii) is preferred.

[0080]

For the purpose of obtaining a liquid crystal composition suited for use as TN-LCD, STN-LCD or the like, the following compounds are preferably used as the liquid crystal component B. The effects of the present invention can be obtained by using such a liquid crystal component B in combination with the liquid crystal component A.

[0081]

(II-bi): Compounds in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 0, and X^{21} is -CN, in the general formula (II-1). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-1d) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0082]

(II-bii): Compounds in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 1, X^{21} is F or -CN, and Y^{21} and Y^{22} represent H or F, in the general formula (II-1). Specific compounds are compounds having the basic structures of the general formulas (II-1e) to (II-1l) in which the side

chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6f).

[0083]

(II-biii): Compounds in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 0, X^{22} is -CN, and Y^{23}, Y^{24}, W^{21}, and W^{22} represent H or F, in the general formula (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-2a) to (II-2h) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structure of the polar group are represented by the general formulas (II-6a) to (II-6c).

[0084]

(II-biv): Compounds in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 1, Z^{23} is a single bond, $-(CH_2)_2-$, or -COO-, Z^{24} is a single bond, -COO-, or $-C\equiv C-$, X^{22} is F or -CN, and Y^{23}, Y^{24}, W^{21}, and W^{22} represent H or F, in the general formula (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-2i) to (II-2ae) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structure of the polar group are represented by the general formulas (II-6a) to (II-6f).

[0085]

(II-bv): Compounds in R^{23} is an alkyl or alkenyl group having 2

to 5 carbon atoms, and one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO-, or -C≡C-, in the general formula (II-3). Specific compounds are compounds having the basic structures of the general formulas (II-3a) to (II-3x) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0086]

(II-bvi): Compounds in which R^{23} is an alkyl or alkenyl group having 2 to 5 carbon atoms and Y^{25}, Y^{26}, and W^{23} to W^{26} represent H or F, in the general formula (II-3). Specific compounds are compounds having the basic structures of the general formulas (II-3a) to (II-3x) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0087]

(II-bvii): Compounds in which R^{24} is an alkyl or alkenyl group having 2 to 7 carbon atoms and $k^{23}+k^{24}=0$, in the general formula (II-4). Specific compounds are compounds having the basic structures of the general formula (II-4a) in which the side chain groups are (II-5a) to (II-5f), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are (II-6a) to (II-6r).

[0088]

(II-bviii): Compounds in which rings A^{21} to A^{24} represent

trans-1,4-cyclohexylene and at least one hydrogen atom of this ring is substituted with a deuterium atom, in the general formulas (II-1) and (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-1l) and (II-2i) to (II-2ae) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0089]

As described above, in the present invention, preferred is a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compounds shown in these sub-groups (II-bi) to (II-bviii), the content of the compounds as the liquid crystal component B being within a range from 10 to 100% by weight.

[0090]

For the purpose of obtaining a liquid crystal composition suited for use as STN-LCD requiring high reliability as well as active TFT-LCD, IPS, STN-LCD, PDLC, PN-LCD or the like, the following compounds are preferably used as the liquid crystal component B. The effects of the present invention can be obtained by using such a liquid crystal component B in combination with the liquid crystal component A.

[0091]

(II-ci): Compounds in which R^{21} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{21} is 1, one of Z^{21} and Z^{22} is a single bond and other one is a single bond, -COO-, $-(CH_2)_2-$,

or $-(CH_2)_4-$, X^{21} is F, Cl, CF_3, OCF_3, or OCF_2H, and one or two of Y^{21} and Y^{22} represent F, in the general formula (II-1). Specific compounds are compounds having the basic structures of the general formulas (II-1e) to (II-1k) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6d) to (II-6r).

[0092]

(II-cii): Compounds in which R^{22} is an alkyl or alkenyl group having 2 to 5 carbon atoms, k^{22} is 1, Z^{23} is a single bond, $-(CH_2)_2-$, or -COO-, Z^{24} is a single bond, -COO-, or $-C\equiv C-$, X^{22} is F, Cl, CF_3, OCF_3, or OCF_2H, one or two of Y^{23} and Y^{24} represent F, and W^{21} and W^{22} represent H or F, in the general formula (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-2i) to (II-2ae) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6d) to (II-6r).

[0093]

(II-ciii): Compounds in which R^{23} is an alkyl or alkenyl group having 2 to 5 carbon atoms, one of Z^{25} and Z^{26} is a single bond and other one is a single bond, -COO-, or $-C\equiv C-$, X^{23} is F, CF_3, one or two of Y^{25} and Y^{26} represent F, and W^{23} to W^{26} represent H and one or more of W^{23} to W^{26} represent F, in the general formula (II-3). Specific compounds are compounds having the

basic structures of the general formulas (II-3a) to (II-3x) in which the side chain groups are (II-5a) to (II-5d), (II-5ah) to (II-5am) and (II-5av) to (II-5bc) and the partial structured of the polar group are represented by the general formulas (II-6e) and (II-6f).

[0094]

(II-civ): Compounds in which rings A^{21} and A^{24} represent trans-1,4-cyclohexylene and at least three hydrogen atoms of this ring are substituted with a deuterium atom, in the general formulas (II-1) and (II-2). Specific compounds are compounds having the basic structures of the general formulas (II-1a) to (II-1l) and (II-2i) to (II-2ae) in which the side chain groups are (II-5a) to (II-5bc) and the partial structures of the polar group are represented by the general formulas (II-6a) to (II-6r).

[0095]

As described above, in the present invention, preferred is a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compounds shown in these sub-groups (II-ci) to (II-civ), the content of the compounds as the liquid crystal component B being within a range from 10 to 100% by weight.

[0096]

Particularly preferred mode in compounds represented by the general formulas (II-1) to (II-4) includes the liquid crystal component B containing the following compounds.

[0097]

(II-di): Compounds in which R^{21} to R^{24} represent an alkyl group having 2 to 7 carbon atoms, in the general formulas. Compounds in which R^{21} and R^{22} represent an alkenyl group of $CH=CH-(CH_2)_q$ (q is 0 or 2). Specifically, compounds having the basic structures of the general formulas (II-1a), (II-1e), (II-2a), (II-2c), (II-2d), (II-2i), (II-2l), (II-2o), (II-3a), (II-3l), (II-4a) to (II-4c) and (II-4e) have preferably these groups, and the viscosity and viscoelasticity can be reduced when the liquid crystal component B contains at least one compound having an alkyl or alkenyl group.

[0098]

(II-dii): It is preferred that the liquid crystal component B contains at least one compound in which X^{21} to X^{24} represent F, $-OCF_3$, or -CN after selection.

[0099]

(II-diii): If high-speed response is considered to be important, compounds of the general formulas (II-1a), (II-1e), (II-2a), (II-2c), (II-2d), (II-2i), (II-2l), (II-2o), (II-3a), (II-3l) and (II-4a) in which X^{21} to X^{24} represent F, Cl, $-OCF_3$, or -CN are preferably used in a large amount based on the crystal liquid component B.

[0100]

(II-div): If larger birefringent index is required, compounds of the general formulas (II-2a) to (II-4d) in which X^{22} to X^{24} represent Cl, $-OCF_3$, or -CN and compounds of the general formulas (II-2a) to (II-4d), and/or Z^{24} and Z^{26} represent $-C\equiv C-$ in the general formulas (II-2f) to (II-2h), (II-2o) to (II-

2q), (II-2ab) to (II-2ae), (II-3k) to (II-3x) are preferably used in a large amount based on the crystal liquid component B.

[0101]

(II-dv): If lower driving voltage is required, compounds of the general formulas (II-1a) to (II-4g) in which X^{21} to X^{24} represent F, Cl, or -CN and one of a pair of Y^{21} to Y^{24} necessarily represent F are preferably used in a large amount based on the crystal liquid component B.

[0102]

(II-dvi): Although compounds in which hydrogen atoms in the cyclohexane ring of the general formulas (II-1) and (II-2) are substituted with a deuterium atom, these compounds are useful to adjust the elastic constant of the liquid crystal composition and to adjust the pre-tilt angle corresponding to the alignment film. Therefore, the liquid crystal component B preferably contains at least one compound substituted with a deuterium atom.

[0103]

(II-dvii): A mixing ratio of the component "dicyclized compound in which k^{21} to k^{24} represent 0 in the general formulas (II-1), (II-2) and (II-4)" to the component "compound in which k^{21} and k^{22} represent 1 in the general formulas (II-1) and (II-2), compound in which $k^{23}+k^{24}=1$ in the general formula (II-4) and/or tricyclized compound of the general formula (II-3)" can be appropriately selected within a range from 0 to 100 (10 to 0). If higher nematic phase-isotropic liquid phase

transition temperature is required, "compound in which k^{21} and k^{22} represent 1 in the general formulas (II-1) and (II-2), compound in which $k^{23}+k^{24}=1$ in the general formula (II-4) and/or tricyclized compound of the general formula (II-3)" are preferably used in a large amount based on the crystal liquid component B.

[0104]

The liquid crystal component B containing these compounds (II-ai) to (II-dvii) has a feature that it can be well mixed with the liquid crystal component A as an essential component, and is particularly useful for preparation according to the purpose of the driving voltage, improvement in temperature dependency and improvement in response characteristics. Particularly, compounds of the general formulas (II-1a) to (II-1g), (II-2a) to (II-2q), (II-2u) to (II-2x), (II-2ab) to (II-2ae), (II-3a) to (II-3d), (II-3l) to (II-3r) and (II-4a) to (II-4e) are superior in at least one of individual effects and this effect can be obtained even in the case of small content within a range from 0.1 to 25% by weight based on the total amount of the nematic liquid crystal composition of the present invention.

[0105]

The effect of the liquid crystal component A and liquid crystal component B can also be obtained even if the content of a liquid crystal component C described below is very small. For the purpose of particularly reducing the driving voltage, the content of a liquid crystal component C can be adjusted to

10% by weight or less. In this case, the viscosity of the liquid crystal component C is preferably reduced as small as possible so that the driving voltage is less likely to increase, thereby efficiently improving the response time. For example, the content of the liquid crystal component C is small, the method of attaining this effect by the liquid crystal component B is that the liquid crystal component B preferably contains any of compounds in which X^{21} to X^{24} is F, Cl, $-OCF_3$, or -CN in the general formulas (II-1) to (II-4), compounds in which Y^{21} to Y^{24} represent F in the general formulas (II-1) to (II-4), compounds in which Z^{24} and Z^{25} represent -COO- or -C≡C- in the general formulas (II-1) to (II-4) and compounds in which k^{11} is 1 in the general formulas (II-1) to (II-4). Particularly, compounds in which X^{21} to X^{24} represent F, Cl, $-OCF_3$ or -CN in the general formulas (II-1) to (II-4) and/or compounds in which Y^{21} to Y^{23} represent F in the general formulas (II-1) to (II-4) are preferred.

[0106]

The liquid crystal composition of the present invention preferably contains 85% by weight or less of the liquid crystal component C having a dielectric constant anisotropy within a range from -10 to 2, in addition to the liquid crystal component A as an essential component. Preferred examples of the liquid crystal component having a dielectric constant anisotropy within a range from -10 to 2 are as follows. That is, it is a compound which has a bar-like chemical structure, the center portion having a core structure

with one to four six-membered rings, the six-membered ring positioned at both terminals in the major axis direction of the center portion having a terminal group substituted at the position corresponding to the direction of the major axis of the liquid crystal, the both of terminal groups, which are present at both terminals, being a non-polar group, for example, alkyl group, alkoxy group, alkoxyalkyl group, alkenyl group, alkenyloxy group, alkanoyloxy group or the like. The liquid crystal composition of the present invention is preferably composed of one to forty kinds, and more preferably two to twenty kinds of the liquid crystal component.

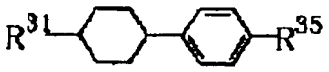
[0107]

From such a point of view, more preferred mode of the basic structure in compounds represented by the general formulas (III-1) to (III-4) includes compounds represented by the general formulas (III-1a) to (III-4o). The liquid crystal composition preferably contains 10 to 100% by weight of compounds selected from compounds represented by the general formulas (III-1) to (III-4) as the liquid crystal component C of the present invention. The liquid crystal component C containing these compounds has a feature that it can be well mixed with the liquid crystal component A containing compounds of the general formulas (I-1) to (I-3), and is particularly useful to improve the nematic phase at low temperature, and also can adjust the desired birefringent index and improve the sharpness, response characteristics and temperature characteristics thereof of TN-LCDs, STN-LCDs, TFT-LCDs, PDLCs,

PN-LCDs or the like.

[0108]

[Chemical Formula 33]

(III-1a) 

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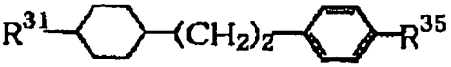
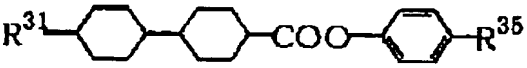
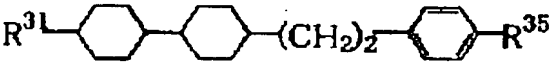
(III-1c) 

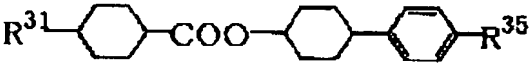
(III-1d) 

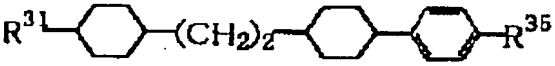
(III-1e) 

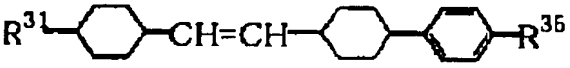
(III-1f) 

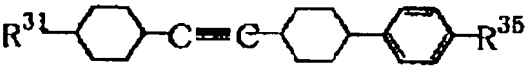
(III-1g) 

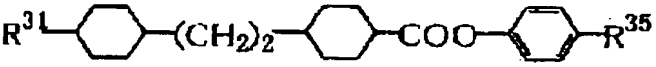
(III-1h) 

(III-1i) 

(III-1j) 

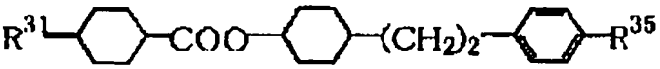
(III-1k) 

(III-1l) 

(III-1m) 

(III-1n) 

(III-1o) 

(III-1p) 

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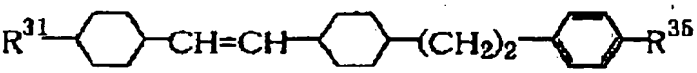
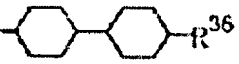
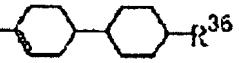
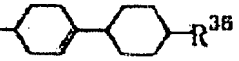
(III-1r) 

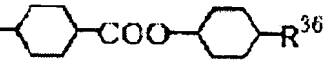
[0109]

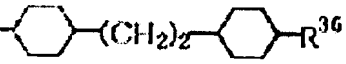
[Chemical Formula 34]

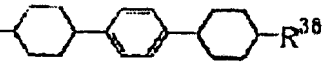
(III-2a) 

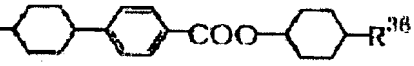
(III-2b) 

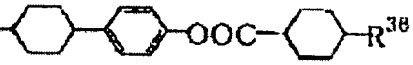
(III-2c) 

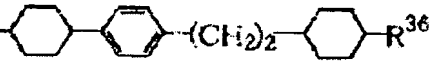
(III-2d) 

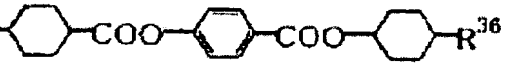
(III-2e) 

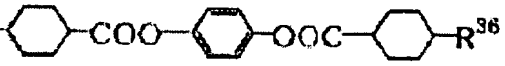
(III-2f) 

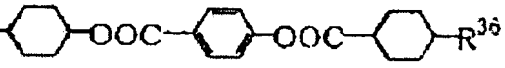
(III-2g) 

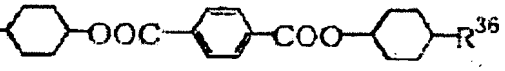
(III-2h) 

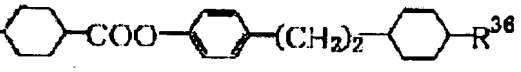
(III-2i) 

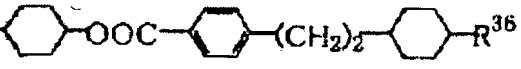
(III-2j) 

(III-2k) 

(III-2l) 

(III-2m) 

(III-2n) 

(III-2o) 

[0110]

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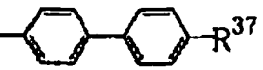
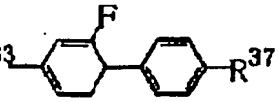
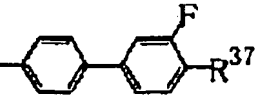
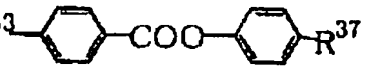
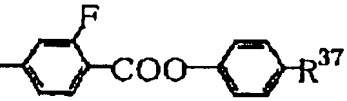
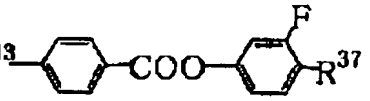
(III-3a) 

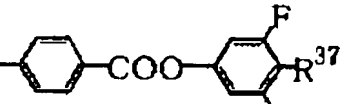
(III-3b) 

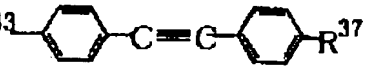
(III-3c) 

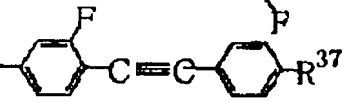
(III-3d) 

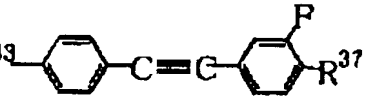
(III-3e) 

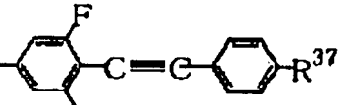
(III-3f) 

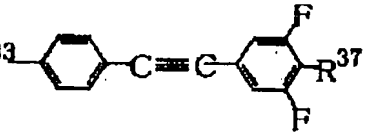
(III-3g) 

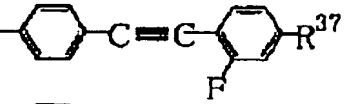
(III-3h) 

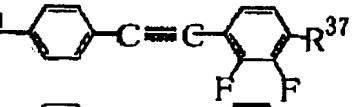
(III-3i) 

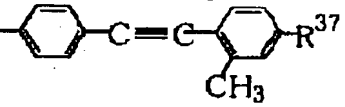
(III-3j) 

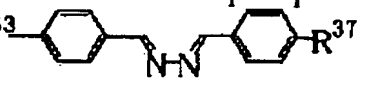
(III-3k) 

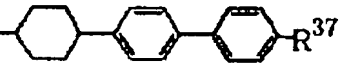
(III-3l) 

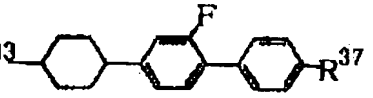
(III-3m) 

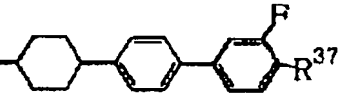
(III-3n) 

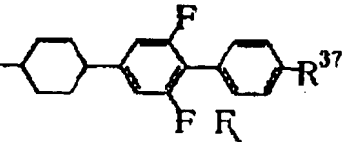
(III-3o) 

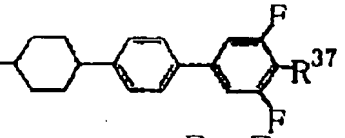
(III-3p) 

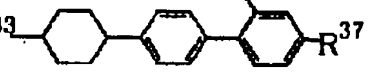
(III-3q) 

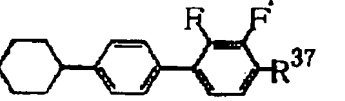
(III-3r) 

(III-3s) 

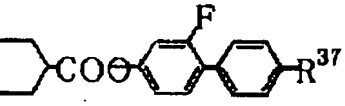
(III-3t) 

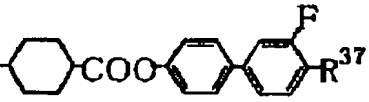
(III-3u) 

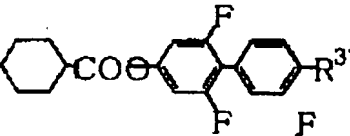
(III-3v) 

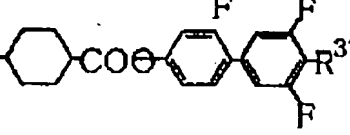
(III-3w) 

(III-3x) 

(III-3y) 

(III-3z) 

(III-3aa) 

(III-3ab) 

[0111]

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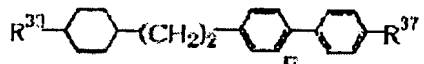
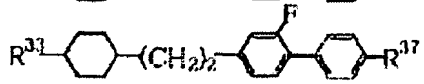
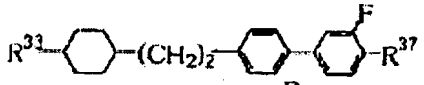
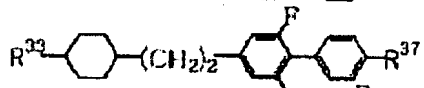
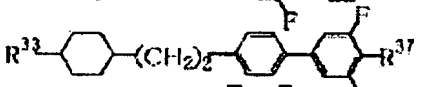
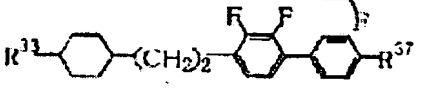
(III-3ac) 

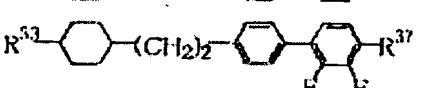
(III-3ad) 

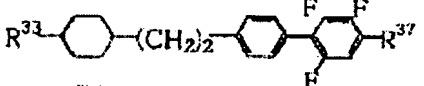
(III-3ae) 

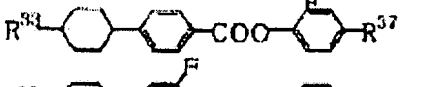
(III-3af) 

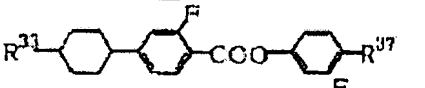
(III-3ag) 

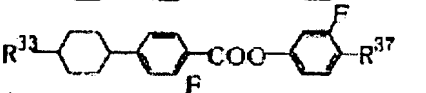
(III-3ah) 

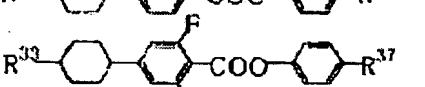
(III-3ai) 

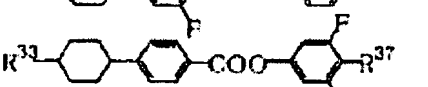
(III-3aj) 

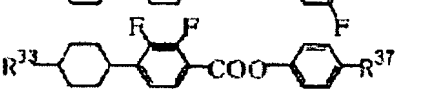
(III-3ak) 

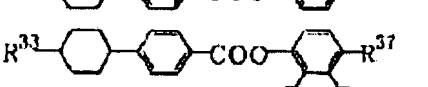
(III-3al) 

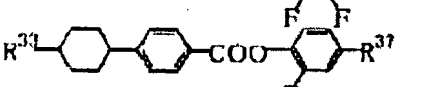
(III-3am) 

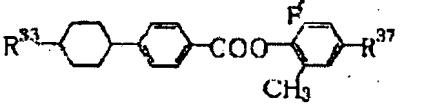
(III-3an) 

(III-3ao) 

(III-3ap) 

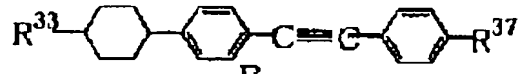
(III-3aq) 

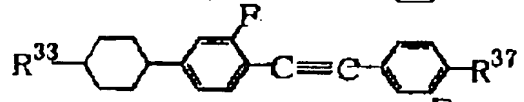
(III-3ar) 

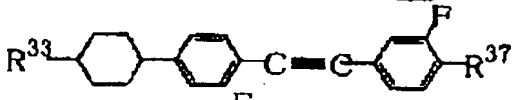
(III-3as) 

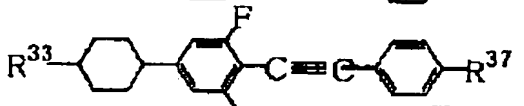
[0112]

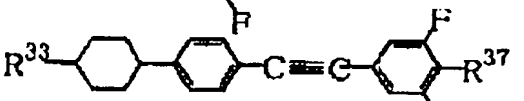
[Chemical Formula 37]

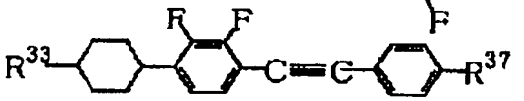
(III-3at) 

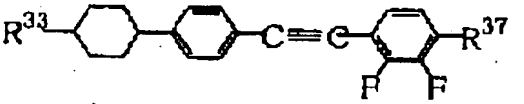
(III-3au) 

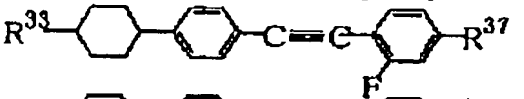
(III-3av) 

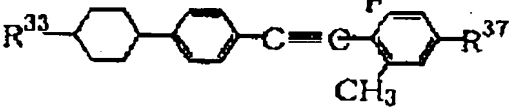
(III-3aw) 

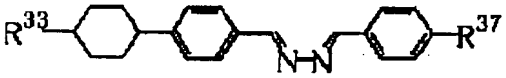
(III-3ax) 

(III-3ay) 

(III-3az) 

(III-3ba) 

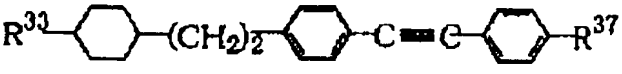
(III-3bb) 

(III-3bc) 

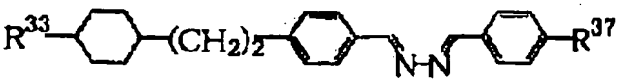
(III-3bd) 

(III-3be) 

(III-3bf) 

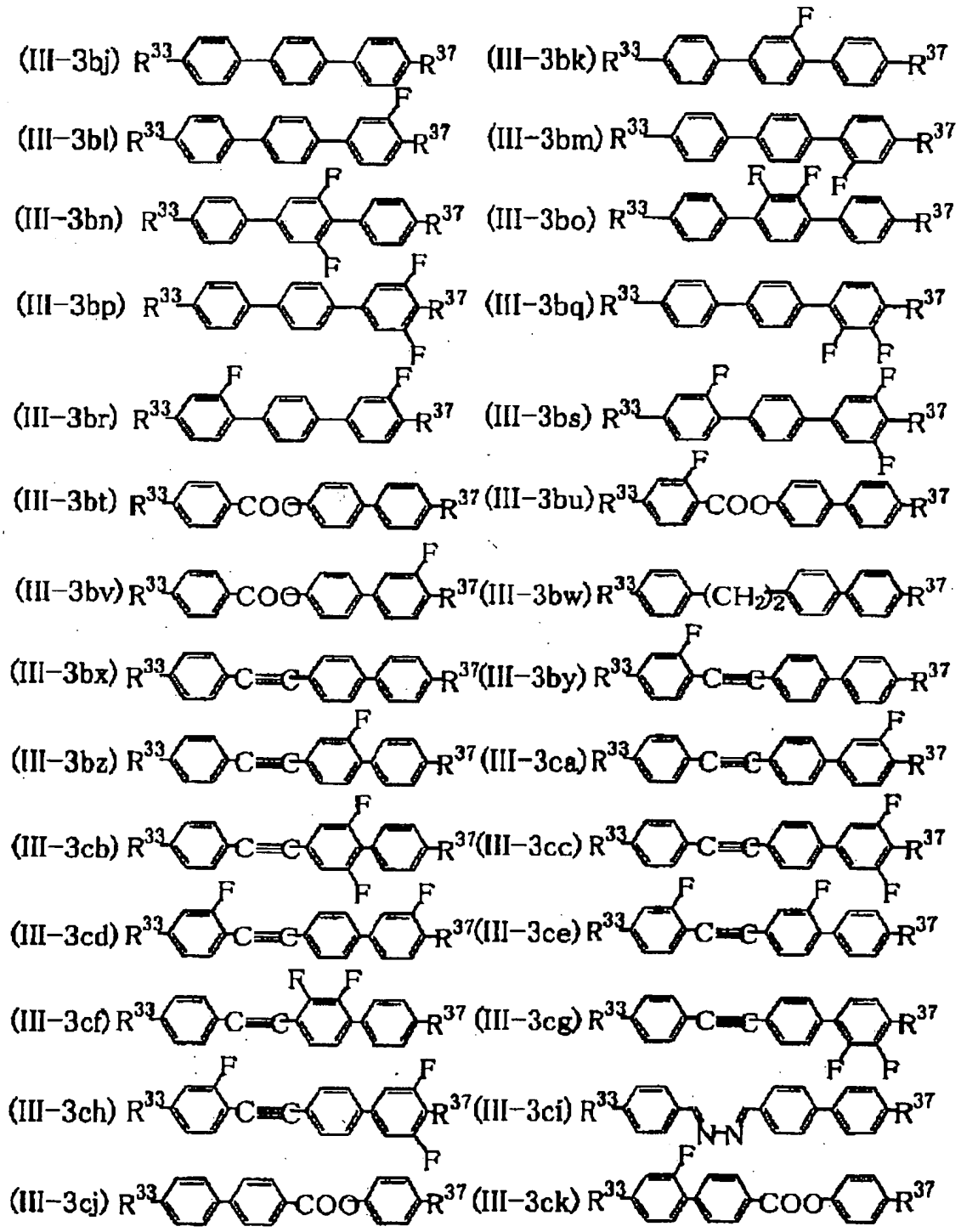
(III-3bg) 

(III-3bh) 

(III-3bi) 

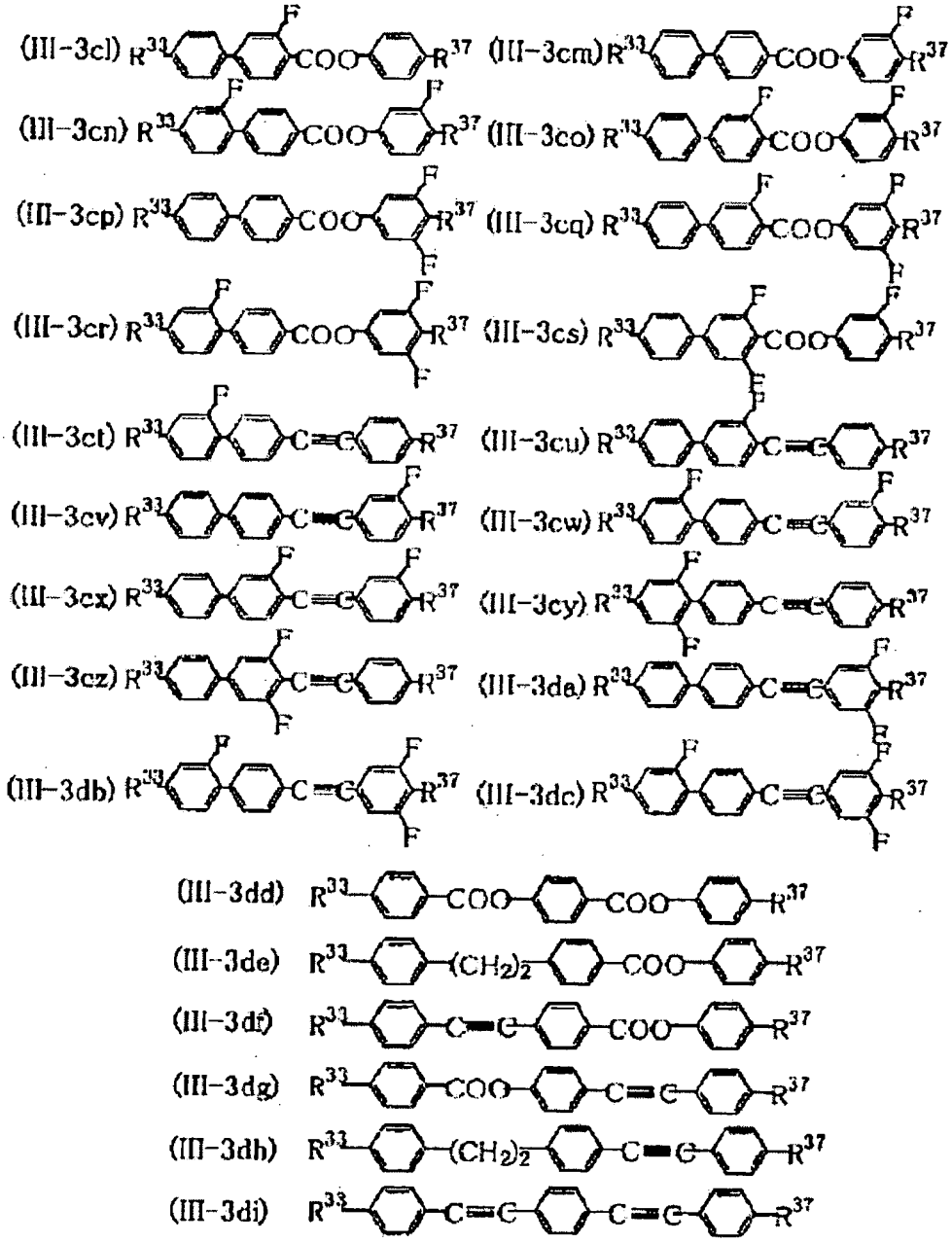
[0113]

[Chemical Formula 38]



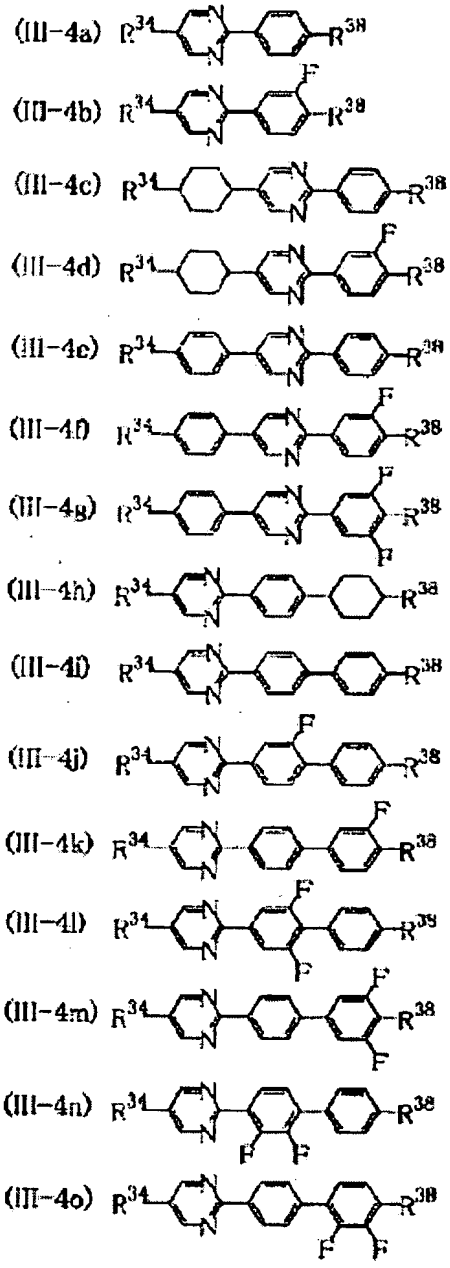
[0114]

[Chemical Formula 39]



[0115]

[Chemical Formula 40]



More preferred mode of the formulas (III-51) and (II-58):

[0116]

[Chemical Formula 41]

(III-51) R^{31}— (III-52) R^{32}— (III-53) R^{33}— (III-54) R^{34}—
(III-55) R^{35}— (III-56) R^{36}— (III-57) R^{37}— (III-58) R^{38}—

in side chain groups R^{31} and R^{38} are compounds represented by the general formulas (III-5a) to (III-5bf) described below.

[0117]

[Chemical Formula 42]

(III-5a) CH_3—
(III-5b) C_2H_5—
(III-5c) C_3H_7—
(III-5d) C_4H_9—
(III-5e) C_5H_{11}—
(III-5f) C_6H_{13}—
(III-5g) C_7H_{15}—

(III-5h) CH_3O—
(III-5i) C_2H_5O—
(III-5j) C_3H_7O—
(III-5k) C_4H_9O—
(III-5l) $C_5H_{11}O$—
(III-5m) $C_6H_{13}O$—
(III-5n) $C_7H_{15}O$—

(III-5o) CH_3COO—
(III-5p) C_2H_5COO—
(III-5q) C_3H_7COO—
(III-5r) C_4H_9COO—
(III-5s) $C_5H_{11}COO$—
(III-5t) $C_6H_{13}COO$—
(III-5u) $C_7H_{15}COO$—

(III-5v) CH_3OCH_2—
(III-5w) $CH_3OC_2H_4$—
(III-5x) $CH_3OC_3H_6$—
(III-5y) $CH_3OC_4H_8$—
(III-5z) $CH_3OC_5H_{10}$—

(III-5aa) $C_2H_5OCH_2$—
(III-5ab) $C_2H_5OC_2H_4$—
(III-5ac) $C_2H_5OC_3H_6$—
(III-5ad) $C_2H_5OC_4H_8$—
(III-5ae) $C_2H_5OC_5H_{10}$—

(III-5af) $C_3H_7OCH_2$—
(III-5ag) $C_3H_7OC_2H_4$—
(III-5ah) $C_3H_7OC_3H_6$—
(III-5ai) $C_3H_7OC_4H_8$—
(III-5aj) $C_3H_7OC_5H_{10}$—

(III-5ak) $CH_2=CH$—
(III-5al) $CH_3CH=CH$—
(III-5am) $C_2H_5CH=CH$—
(III-5an) $C_3H_7CH=CH$—
(III-5ao) $CH_2=CHC_2H_4$—
(III-5ap) $CH_3CH_2=CHC_2H_4$—
(III-5aq) $CH_2=CHC_2H_5CH=CH$—

(III-5ar) $CH_2=CHO$—
(III-5as) $CH_3CH=CHO$—
(III-5at) $C_2H_5CH=CHO$—
(III-5au) $C_3H_7CH=CHO$—
(III-5av) $CH_2=CHC_2H_4O$—
(III-5aw) $CH_3CH_2=CHC_2H_4O$—
(III-5ax) $CH_2=CHC_2H_5CH=CHO$—

(III-5ay) CHF=CH—
(III-5az) $CH_2=CF$—
(III-5ba) $CF_2=CH$—
(III-5bb) CHF=CF—

(III-5bc) CHF=CHC_2H_4—
(III-5bd) $CH_2=CFC_2H_4$—
(III-5be) $CF_2=CHC_2H_4$—
(III-5bf) CHF=CFC_2H_4—

The respective compounds are used after sufficient purification by removing impurities using a means such as distillation, column purification, recrystallization or the like.

[0118]

The liquid crystal component C can contain compounds represented by the general formulas (III-1) to (III-4), but may be composed of compounds represented by the general formula (III-1), compounds represented by the general formula (III-2), compounds represented by the general formula (III-3), compounds represented by the general formula (III-4), or a combination thereof. More preferably, the nematic liquid crystal composition contains the liquid crystal component C containing one, or two or more kinds of compounds selected from compounds represented by the general formulas (III-1) to (III-3), the content of the compounds being within a range from 10 to 100% by weight.

[0119]

In more detail, if a general liquid crystal composition is prepared, the following compounds are preferably used as the liquid crystal component C, and the effects of the present invention can be obtained by using the liquid crystal component C in combination with the liquid crystal component A or B.

[0120]

(III-ai): Compounds in which R^{31} to R^{34} represent an alkenyl

group having 2 to 5 carbon atoms, in the general formulas (III-1) to (III-4), and specifically compounds having the basic structures of the general formulas (III-1a) to (III-4o) in which side chain group R^{35} to R^{38} represents (III-5a) to (II-5bf) and side chain group R^{31} to R^{34} represents (III-5ak) to (II-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf), which improve the response characteristics by a reduction in viscosity and viscoelasticity and improve the nematic phase-isotropic liquid phase transition temperature, thus obtaining more improved electro-optical characteristics of TN-LCDs, STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0121]

(III-aii): Compounds in which R^{35} to R^{38} is a straight-chain alkenyl or alkenyloxy group having 2 to 7 carbon atoms, in the general formulas (III-1) to (III-4), and specifically compounds having the basic structures of the general formulas (III-1a) to (III-4o) in which the side chain group R^{31} to R^{34} represents (III-5a) to (II-5bf) and the side chain group R^{35} to R^{38} represents (III-5ak) to (III-5bf). These compounds improve the response characteristics by a reduction in viscosity and viscoelasticity and improve the nematic phase-isotropic liquid phase transition temperature, thus obtaining more improved electro-optical characteristics of TN-LCDs, STN-LCDs, TFT-LCDs, PDLCs, PN-LCDs or the like.

[0122]

(III-aiii): Compounds in which k^{31} is 0 and Z^{32} is a single bond or $-(CH_2)_2-$, in the general formula (III-1), and

specifically compounds having the basic structures of the general formulas (III-1a) and (III-1c) in which side chain groups R^2 and R^3 are (III-5a) to (III-5bf).

[0123]

(III-aiv): Compounds in which k^{31} is 1, in the general formula (III-1), and specifically compounds having the basic structures of the general formulas (III-1d) to (III-1r) in which side chain groups are (III-5a) to (III-5bf).

[0124]

(III-av): Compounds represented by the general formula (III-2), and specifically compounds having the basic structures of the general formulas (III-2a) to (III-2o) in which side chain groups are (III-5a) to (III-5bf).

[0125]

(III-avi): Compounds in which at least one of Y^{34}, Y^{35}, and W^{34} to W^{36} is F and/or Y^{33} is F or $-CH_3$, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3b), (III-3c), (III-3e), (III-3g), (III-3i) to (III-3o), (III-3r) to (III-3w), (III-3y) to (III-3ab), (III-3ad) to (III-3aj), (III-3al) to (III-3as), (III-3au) to (III-3az), (III-3bb), (III-3bk) to (III-3bs), (III-3bu), (III-3bv), (III-3by) to (III-3ch) and (III-3ck) to (III-3dc) in which side chain groups are (III-5a) to (III-5bf).

[0126]

(III-avii): Compounds in which k^{33} is 0 and Z^{36} is a single bond, in the general formula (III-3), and specifically

compounds having the basic structures of the general formulas (III-3a) to (III-3c) in which side chain groups are (III-5a) to (III-5bf).

[0127]

(III-aviii): Compounds in which k^{33} is 1 and Z^{35} is a single bond, -OCO-, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, -CH=CH-$(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, -N(O)=N-, -CH=CH-, or -CF=CF-, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3q) to (III-3w), (III-3ac) to (III-3bc), (III-3be), (III-3bg), (III-3bi) to (III-3bs), (III-3bw), (III-3ci) to (III-3dc), (III-3de) and (III-3dh) in which side chain groups are (III-5a) to (III-5bf).

[0128]

(III-aix): Compounds in which Z^{35} is -COO- or -C≡C- and Z^{36} is -OCO-, $-CH_2O-$, $-OCH_2-$, $-(CH_2)_2-$, $-(CH_2)_4-$, -CH=CH-$(CH_2)_2-$, $-(CH_2)_2-CH=CH-$, -CH=N-, -CH=N-N=CH-, -N(O)=N-, -CH=CH-, or -CF=CF-, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3bf), (III-3bh), (III-3df) and (III-3dg) in which side chain groups are (III-5a) to (III-5bf).

[0129]

(III-ax): Compounds represented by the general formula (III-4), and specifically compounds having the basic structures of the general formulas (III-4a) to (III-4o) in which side chain groups are (III-5a) to (III-5bf).

[0130]

(III-axi): Compounds selected from compounds in which rings A^{31} to A^{35} represent trans-1,4-cyclohexylene and at least one of hydrogen atoms of these rings is substituted with a deuterium atom, in the general formulas (III-1) to (III-4), and specifically compounds having the basic structures of the general formulas (III-1a) to (III-2o), (III-3q) to (III-3bi), (III-4c), (III-4d) and (III-4h) in which side chain groups are (III-5a) to (III-5bf).

[0131]

As described above, in the present invention, a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compounds shown in these sub-groups (III-ai) to (III-axi), the content of said compounds as the liquid crystal component C being from 10 to 100% by weight, is preferred.

[0132]

Preferred mode in compounds represented by the general formulas (III-1) to (III-4) is a liquid crystal component C containing the following compounds.

[0133]

(III-bi): Compounds in which R^{31} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{35} is an alkyl or alkoxy group having 1 to 5 carbon atoms, or alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{31} is 0, and Z^{32} is a single bond, -COO-, or $-(CH_2)_2-$, in the general formula (III-1), and specifically compounds having the basic

structures of the general formulas (III-1a) to (III-1c) in which the side chain group R^{31} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{35} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0134]

(III-bii): k^{31} is 1, the ring A^{31} is trans-1,4-cyclohexylene, and one of Z^{31} and Z^{32} is a single bond and other one is a single bond, -COO, or $-(CH_2)_2-$, in the general formula (III-1), and specifically compounds having the basic structures of the general formulas (III-1d), (III-1g) to (III-1j) in which the side chain group R^{31} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{35} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0135]

(III-biii): Compounds in which R^{32} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{36} is an alkyl or alkoxy group having 1 to 5 carbon atoms, or alkenyl or alkenyloxy group having 2 to 5 carbon atoms, the ring A^{32} is trans-1,4-cyclohexylene or trans-1,4-cyclohexenylene, k^{32} is 0, and Z^{33} is a single bond, -COO, or $-(CH_2)_2-$, in the general formula (III-2), and specifically compounds having the basic structures of the general formulas (III-2a), (III-2d) and (III-2e) in which the side chain group R^{32} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap)

and the side chain group R^{36} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0136]

(III-biv): k^{32} is 1, and one of Z^{33} and Z^{34} is a single bond, in the general formula (III-2), and specifically compounds having the basic structures of the general formulas (III-2f) to (III-2i) in which the side chain group R^{32} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{36} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0137]

(III-bv): Compounds in which R^{33} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{37} is an alkyl or alkoxy group having 1 to 5 carbon atoms, or alkenyl or alkenyloxy group having 2 to 5 carbon atoms, k^{33} is 0, and Z^{38} is a single bond, -C≡C-, or -CH=N-N=CH, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3a) to (III-3c) and (III-3h) to (III-3p) in which the side chain group R^{33} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{37} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0138]

(III-bvi): k^{33} is 1, Z^{35} is a single bond, $-(CH_2)_2-$, -COO-,

or -C≡C-, and Z^{36} is a single bond, -COO-, or -C≡C-, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3q) to (III-3bb), (III-3bd) to (III-3bg), (III-3bj) to (III-3ch) and (III-3cj) to (III-3di) in which the side chain group R^{33} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{37} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0139]

(III-bvii): Z^{35} and Z^{36} is a single bond and other one is a single bond or -C≡C-, and at least one of W^{34} and W^{35} is F, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3r), (III-3t), (III-3au), (III-3aw), (III-3ay), (III-3bk), (III-3bn), (III-3bo), (III-3bz), (III-3cb), (III-3ce), (III-3cf), (III-3cu), (III-3cx) and (III-3cz) in which the side chain group R^{33} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{37} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0140]

(III-bviii): Compounds in which R^{33} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{37} is an alkyl or alkoxy group having 1 to 5 carbon atoms, or alkenyl or alkenyloxy group having 2 to 5 carbon

atoms, and any one of Y^{35} and Y^{36} is substituted with F or CH_3, in the general formula (III-3), and specifically compounds having the basic structures of the general formulas (III-3c), (III-3f), (III-3g), (III-3j), (III-3l) to (III-3o), (III-3s), (III-3u) to (III-3w), (III-3z), (III-3ab), (III-3ae), (III-3ag), (III-3ai), (III-3aj), (III-3am), (III-3ao), (III-3aq) to (III-3as), (III-3av), (III-3ax), (III-3az) to (III-3bb), (III-3bl), (III-3bm), (III-3bp) to (III-3bs), (III-3bv), (III-3ca), (III-3cc), (III-3cd), (III-3cg), (III-3ch), (III-3cm) to (III-3cs), (III-3cv) to (III-3cx) and (III-3da) to (III-3dc) in which the side chain group R^{33} represents (III-5a) to (III-5e), (III-5ak) to (III-5ap) and the side chain group R^{37} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0141]

(III-bix): Compounds in which R^{34} is an alkyl group having 1 to 5 carbon atoms or an alkenyl group having 2 to 5 carbon atoms, R^{38} is an alkyl or alkoxy group having 1 to 5 carbon atoms, or alkenyl or alkenyloxy group having 2 to 5 carbon atoms, and $k^{34}+k^{35}=0$, in the general formula (III-4), and specifically compounds having the basic structures of the general formulas (III-4a) and (III-4b) in which the side chain group R^{34} represents (III-5a) to (III-5e) and (III-5ak) to (III-5ap) and the side chain group R^{38} represents (III-5a) to (III-5e), (III-5g) to (III-5l), (III-5ak) to (III-5ap), (III-5ar) to (III-5aw) and (III-5ay) to (III-5bf).

[0142]

Preferred is a nematic liquid crystal composition containing one, or two or more kinds of compounds selected from compounds shown in these sub-groups (III-bi) to (III-bix), the content of the compounds as the liquid crystal component C being within a range from 10 to 100% by weight.

Preferred mode in compounds represented by the general formulas (III-1) to (III-4) is a liquid crystal component C containing the following compounds.

[0143]

The liquid crystal composition containing compounds of the general formulas (III-1) to (III-4) as the liquid crystal component C has a feature that it can reduce the viscosity and viscoelasticity, thus leading to comparatively high holding ratio of the resistivity and voltage. The viscosity of the liquid crystal component C is preferably small as possible. In the present invention, the viscosity is preferably 45 cp or less, more preferably 30 cp or less, still more preferably 20 cp or less, and particularly preferably 15 cp or less.

[0144]

From such a point of view, preferred compounds are compounds (III-ci) having the structures represented by the general formulas (III-1a) to (III-1f), (III-1k), (III-2a) to (III-2f), (III-3a), (III-3h) to (III-3j), (III-3o), (III-3p), (III-3q), (III-3ac), (III-3at) to (III-3ax), (III-3ba), (III-3bb), (III-3bf), (III-3bg), (III-3bx) to (III-3cb) and (III-3ct) to (III-3cx),

[0145]

preferably compounds (III-ci) in which R^{31} to R^{34} represents a straight-chain alkyl group having 2 to 5 carbon atoms or an alkenyl group of $CH=CH-(CH_2)_q$ (q=0 or 2) and R^{35} to R^{38} represents a straight-chain alkyl group having 1 to 5 carbon atoms or an alkenyl group of $CH=CH-(CH_2)_q$(q=0 or 2) among the compounds (III-ci),

[0146]

and more preferably compounds (III-ciii) having the structure represented by the general formulas (III-1a), (III-1d), (III-2a), (III-2f), (III-3a), (III-3h), (III-3p) and (III-3q) in which both side chain groups are alkenyl groups.

[0147]

Although the liquid crystal component C of the present invention can be composed of each of the compounds represented by the general formulas (III-1), (III-2), (III-3) and (III-4) alone, the birefringent index of the liquid crystal composition can be easily optimized according to applications by using (III-civ): "compounds represented by the general formulas (III-1) and/or (III-2), and particularly compounds of the general formulas (III-1a), (III-1d), (III-2a) to (III-2c) and (III-f)" in combination with (III-cv): "compounds represented by the general formulas (III-3) and/or (III-4), particularly compounds in which Z^{35} is a single bond, -C≡C-, or -CH=N-N=CH- in the general formula (III-3), and specifically compounds of the general formulas (III-3a), (III-3h), (III-3p), (III-3q), (III-3at), (III-4a) and (III-4h)" (III-cv). Generally, the birefringent index can be reduced by

using the compounds of the general formulas (III-1) and (III-2), for example, compounds of the general formulas (III-1a) to (III-2f) in a large amount, thereby making it possible to easily attain an reduction in color irregularity of the liquid crystal display device, an improvement in viewing angle characteristics and an increase in contrast ratio. The birefringent index can be enhanced by using the compounds of the general formulas (III-3), for example, compounds of the general formulas (III-3a) to (III-3j), or compounds of the general formulas (III-4), for example, compounds of the general formulas (III-4a) to (III-4e) in a large amount, thereby making it possible to produce a thin liquid crystal display element having a liquid crystal layer having a thickness within a range from 1 to 5 μm.

[0148]

The liquid crystal component C containing these compounds (III-ai) to (III-cv) has a feature that it can be well mixed with the liquid crystal component A as an essential component, and is particularly useful for preparation according to the purpose of the driving voltage, improvement in temperature dependency and improvement in response characteristics. These compounds are superior in at least one of individual effects and this effect can be obtained even in the case of small content within a range from 0.1 to 30% by weight based on the total amount of the nematic liquid crystal composition of the present invention.

[0149]

The alignment film used in TN-LCDs, STN-LCDs or TFT-LCDs is exclusively a polyimide film and examples thereof include LX1400, SE150, SE610, AL1051, AL3408 and the like. Liquid crystal display characteristics, display quality, reliability and productivity have a close relation with the specification of the alignment film and, for example, pre-tilt angle characteristics are important to the liquid crystal material. The pre-tilt angle must be appropriately adjusted to obtain desired liquid crystal display characteristics and uniform alignment properties. In the case of a large pre-tilt angle, unstable oriented state is liable to occur. In the case of a small pre-tilt angle, it becomes impossible to satisfy sufficient display characteristics.

[0150]

The present inventors have found that liquid crystal materials are classified into a liquid crystal material having a larger pre-tilt angle and a liquid crystal material having a smaller pre-tilt angle, and also found that the desired liquid crystal display characteristics and uniform alignment properties are attained by applying this classifying technique. This technique can also be applied to the present invention. If the liquid crystal component B contains compounds of the general formulas (II-1) to (II-4), the pre-tilt angle is controlled in the following manner. Larger pre-tilt angle can be obtained by increasing the content of compounds in which R^{21} is an alkenyl group, X^{21} is F, Cl, or -CN, and Y^{21} and Y^{22} represent F and/or compounds in which

R^{21} is an alkenyl group, X^{21} is F, Cl, or -CN, and Z^{22} is $-C_2H_4-$ or $-C_4H_8-$, while smaller pre-tilt angle can be obtained by increasing the content of compounds in which R^{21} is an alkenyl group or $C_sH_{2s+1}-O-C_tH_{2t}$, X^{21} is F, Y^{21} is F, and Y^{22} is H and/or compounds in which Z^{22} is -COO-. Specifically, in the case of compounds in which rings A^{11} to A^{16} in the general formulas (I-1) to (I-3), are cyclohexane rings, or rings A^{21} to A^{24} in the general formulas (II-1), (II-2) and (II-4) are cyclohexane rings, or rings A^{31} to A^{35} in the general formulas (III-1) to (III-4) are cyclohexane rings, and hydrogen atoms of the rings are substituted with deuterium atoms, it makes possible to adjust the pre-tilt angle within a wide range, though it varies depending on the substitution position. Use of a large amount of compounds in which hydrogen atoms are substituted with deuterium atoms exerts a noticeable effect of maintaining higher voltage holding ratio, and is suited for display characteristics and production yield of active TFT-LCDs, PDLCs, PN-LCDs or the like. It is considered that such an effect is obtained by incorporating the above-described compounds in the amount within a range from 10 to 40% by weight based on the total amount of the liquid crystal composition.

[0151]

Generally, the content of each liquid crystal component in the nematic liquid crystal composition of the present invention is as follows. The content of the liquid crystal component A is within a range from 0.1 to 100% by weight,

preferably from 0.5 to 90% by weight, and more preferably from 5 to 85% by weight. The content of the liquid crystal component B is within a range from 0 to 99.9% by weight, preferably from 3 to 80% by weight, and more preferably from 5 to 60% by weight. The content of the liquid crystal component C is 85% by weight or less, preferably within a range from 3 to 70% by weight, more preferably from 5 to 70% by weight. When using the compounds represented by the general formula (I-1), the content is preferably 15% by weight or less in terms of single substance. The content of compounds represented by the general formulas (I-1a) to (I-3ab) is preferably within a range from 5 to 100% by weight based on the liquid crystal component A. The content of compounds represented by the general formulas (II-1) to (II-4), and specifically compounds represented by the general formulas (II-1a) to (II-4g) is preferably 30% by weight or less, and more preferably 25% by weight or less, in terms of single substance. If the content is 30% or more, the compounds are preferably composed of two or more kinds of compounds and the content is within a rage from 10 to 100% by weight, preferably from 50 to 100% by weight, and more preferably from 75 to 100% by weight, based on the liquid crystal component B. The content of compounds represented by the general formulas (III-1) to (III-4), and specifically compounds represented by the general formulas (III-1a) to (III-4o) is preferably 30% by weight or less, and more preferably 25% by weight or less, in terms of single substance. If the content is 30% or more, the

compounds are preferably composed of two or more kinds of compounds and the content is within a rage from 10 to 100% by weight, preferably from 50 to 100% by weight, and more preferably from 75 to 100% by weight, based on the liquid crystal component C.

[0152]

The liquid crystal composition of the present invention may contain conventional nematic liquid crystals, smectic liquid crystals and chloresteric crystals recognized as liquid crystal compounds, in addition to compounds represented by the general formulas (I-1) to (III-4), in order to improve characteristics of the liquid crystal composition. For example, the liquid crystal composition contain one, or two more kinds of core-structure compounds having four six-membered rings, the liquid crystal phase-isotropic liquid phase transition temperature of said compounds being 100°C or higher. However, since characteristics of the nematic liquid crystal composition are deteriorated by using a large amount of these compounds, the amount is limited according to required characteristics of the resulting nematic liquid crystal composition.

[0153]

Crystal phase or smectic phase-nematic phase transition temperature should be 0°C or lower, preferably -10°C or lower, more preferably -20°C or lower and most preferably -30°C or lower. The nematic phase-isotropic liquid phase transition temperature is preferably 60°C or higher, more preferably 70°C

or higher and most preferably within a range from 80°C to 180°C. The dielectric constant anisotropy of the liquid crystal composition according to the present invention may have a value not less than 3, but is preferably within a range from 4 to 40, while it is preferably within a range from 17 to 30 when high speed response is required and preferably within a range from 4 to 16 when a lower driving voltage is required. Lower or medium birefringent index is preferably within a range from 0.08 to 0.18, and higher birefringent index is preferably within a range from 0.18 to 0.35. Such characteristics of the nematic liquid crystal composition are useful for active matrix, twisted nematic or super twisted nematic liquid crystal display device.

[0154]

When faster response characteristic for the magnitude of the driving voltage is desired, the liquid crystal composition of the present invention may be constituted as follows. For a medium driving voltage, the dielectric constant anisotropy of the liquid crystal composition according to the present invention is from 3 to 15, and viscosity at 20°C is preferably within a range from 8 to 20 cp. In this case, viscosity of only the liquid crystal component C is preferably 25 cp or lower, more preferably 15 cp or lower, and most preferably 10 cp or lower. For a particularly low driving voltage, the dielectric constant anisotropy of the liquid crystal composition according to the present invention is preferably within a range from 15 to 30, and more preferably within a

range from 18 to 28.

[0155]

The nematic liquid crystal composition described above is useful for the use in TN-LCD, STN-LCD and TFT-LCD that have high-speed response characteristic, useful for a liquid crystal display element that is capable of providing color display by means of the birefringent property of a liquid crystal and a retardation plate without using color filters, and can be used in a liquid crystal display element of transmissive type or reflective type. This liquid crystal display element has substrates that have transparent electrode layer, with at least one thereof being transparent, wherein molecules of the nematic liquid crystal composition are disposed in a twisted orientation between the substrates. The twist angle may be selected within a range from 30 to 360° in accordance to the purpose, preferably selected within a range from 90 to 270°, and most preferably selected within a range from 45 to 135° or from 180 to 260°. For this purpose, the liquid crystal composition of the present invention may include a compound that has an optically active group which causes the induced helical pitch p to fall within a range from 0.5 to 1000 μm. Pre-tilt angle obtained from an oriented film that is provided on the transparent electrode substrate is preferably from 1° to 20°. When the twist angle is within a range from 30° to 100°, the pre-tile angle is preferably from 1° to 4°. When the twist angle is within a range from 100° to 180°, the pre-tile angle is preferably from 2° to 6°. When

the twist angle is within a range from 180° to 260°, the pre-tile angle is preferably from 3° to 12°. When the twist angle is within a range from 260° to 360°, the pre-tile angle is preferably from 6° to 20°.

[0156]

The present inventors have found out that favorable display characteristics can be achieved also with a light scattering type liquid crystal display wherein the liquid crystal composition has a light modulation layer held between two transparent substrates, with at least one of which being transparent, having transparent electrode layers, and the light modulation layer includes a liquid crystal material and a transparent solid substance. The present inventors showed, on Japanese Unexamined Patent Application, First Publication No. Hei 6-222320, that the physical properties of a liquid crystal material and the display characteristics of the liquid crystal can be related by the following equation (VI).

[0157]

[Equation 1]

$$Vth \propto \frac{d}{\langle r \rangle + {}^{1}Kii/A} \left(\frac{{}^{2}Kii}{\Delta \varepsilon} \right)^{1/2} \quad \text{---(VI)}$$

where Vth is the threshold voltage, ${}^{1}Kii$ and ${}^{2}Kii$ are elastic constants with ii being 11, 22 or 33, $\Delta\varepsilon$ is the dielectric constant anisotropy, $\langle r \rangle$ is the mean void distance in the interface of the transparent solid substance, A is the anchoring energy of the transparent solid substance and d is

the distance between the substrates having the transparent electrodes.

[0158]

This equation means that the restricting force of the interface of the transparent solid substance exerted on the liquid crystal molecules varies according to the ratio of the elastic constant ^{1}Kii and the anchoring energy A, and particularly shows that the effect thereof is to effectively expand the distance by the amount of ^{1}Kii/A over the actual mean void distance <r>, namely to effectively decrease the driving voltage. This relation can also be utilized in the present invention. Specifically, when the transparent solid substance is formed from a polymerizable compound that includes difunctional monomer and monofunctional monomer which serve as polymer-forming compounds, the transparent solid substance takes a more uniform structure thereby making it possible to manipulate the property of the interface with the liquid crystal material, in the process of forming the transparent solid substance from the polymer-forming compounds. In the liquid crystal composition according to the present invention, one or plural characteristics among clouding characteristics, response characteristics, hysteresis, sharpness and driving voltage, or the temperature dependency of these characteristics can be improved by the liquid crystal component A that consists of a compound characterized by such a molecular structure having naphthalene-2,6-diyl with a polar group as a partial structure

thereof.

[0159]

The liquid crystal material used in the present invention is expected to be useful also for a display apparatus wherein a transparent solid substance interposed between the two substrates that have transparent electrode layers includes liquid crystal droplets, which comprise a liquid crystal material and is contained in microcapsules, being scattered therein. The transparent solid substance interposed between the two substrates may be fibers or particles scattered or a film containing droplets of the liquid material dispersed therein, but more preferably has a three-dimensional network structure. While it is preferable that the liquid crystal material forms a continuous layer, it is important to form random state of the liquid crystal material in order to form an optical interface and achieve scattering of light. When the average size of the three-dimensional network structure formed from the transparent solid substance is too greater or smaller than the wavelength of light, scattering of light tends to be weaker. Thus the average size is preferably from 0.2 to 2 μm. Thickness of the light modulation layer is preferably from 2 to 30 μm, and more preferably from 5 to 20 μm depending on the application.

[0160]

The light scattering type liquid crystal display of the present invention that is made as described above achieves less temperature-dependent drive characteristics and thereby

satisfies the requirements for the active matrix display. The liquid crystal display of the present invention can also be used, for example, in a projection display apparatus and personal digital assistance of direct view type.

[0161]

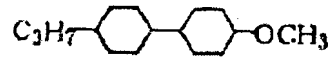
The liquid crystal composition of the present invention can be obtained by incorporating the liquid crystal components A, B and C described in detail above. Preferred examples are nematic liquid crystals (1-01) to (1-24) described below, but the present invention is not limited by these examples. Among these, for example, nematic liquid crystal compositions (1-01), (1-03) to (1-07), (1-10), (1-11) and (1-12) can be used for TN-LCD, nematic liquid crystal compositions (1-01), (1-02), (1-06), (1-07), (1-13), (1-14), (1-17) to (1-22) and (1-24) can be used for STN-LCD, nematic liquid crystal compositions (1-08), (1-09), (1-15) and (1-23) can be used for TFT-LCD, and nematic liquid crystal compositions (1-15) and (1-16) can be used for PDLC and PN-LCD. One or plural kinds of these compounds (1-0101) to (1-2415) can be used in place of compounds represented by the general formulas (I-1) to (III-4), more specifically compounds having the basic structures of the general formulas (I-1a) to (I-3ab) in which the side chain groups are (I-4a) to (I-4bc) and the partial structures of the polar group are represented by the general formulas (I-5a) to (I-5av), compounds having the basic structures of the general formulas (II-1a) to (II-4g) in which the side chain groups are (I-5a) to (I-5bc) and the partial

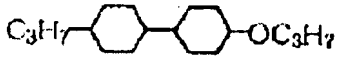
structures of the polar group are represented by the general formulas (II-6a) to (II-6r), and compounds having the basic structures of the general formulas (III-1a) to (III-4o) in which the side chain groups are (III-5a) to (III-5bf), according to the desired purposes and applications.

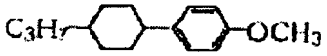
[0162]

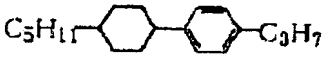
[Chemical Formula 43]

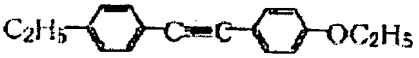
Examples of preferred composition: nematic liquid crystal composition (1-01).

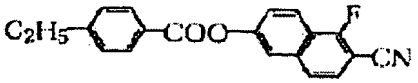
(1-0101)  10 wt%

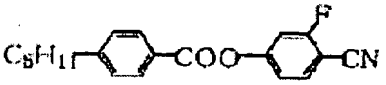
(1-0102)  10 wt%

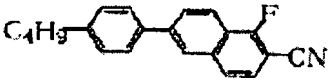
(1-0103)  5 wt%

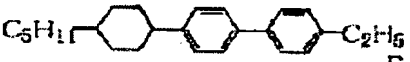
(1-0104)  5 wt%

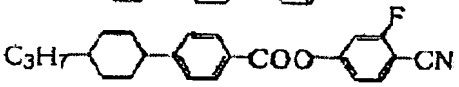
(1-0105)  5 wt%

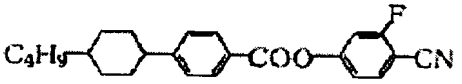
(1-0106)  5 wt%

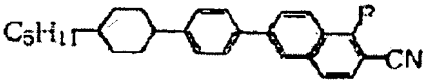
(1-0107)  12 wt%

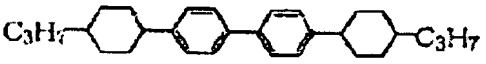
(1-0108)  10 wt%

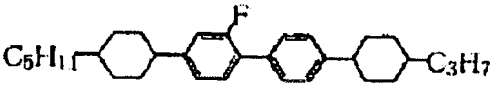
(1-0109)  8 wt%

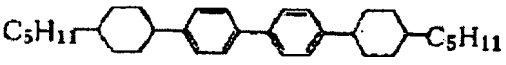
(1-0110)  5 wt%

(1-0111)  5 wt%

(1-0112)  5 wt%

(1-0113)  5 wt%

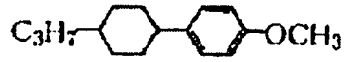
(1-0114)  5 wt%

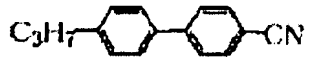
(1-0115)  5 wt%

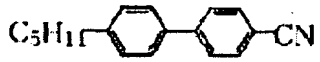
[0163]

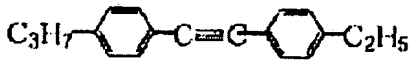
[Chemical Formula 44]

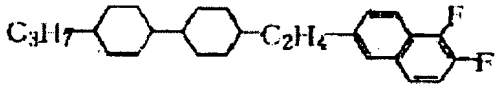
Examples of preferred composition: nematic liquid crystal composition (1-02)

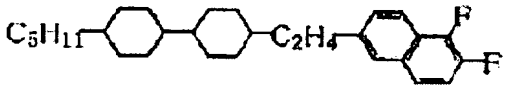
(1-0201)  10 wt%

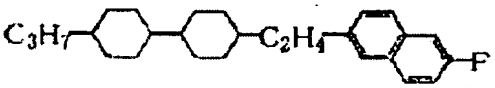
(1-0202)  8 wt%

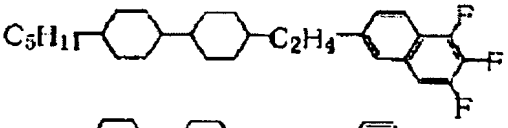
(1-0203)  15 wt%

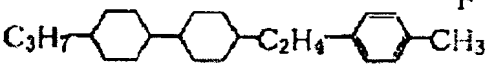
(1-0204)  9 wt%

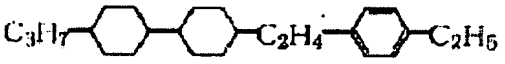
(1-0205)  6 wt%

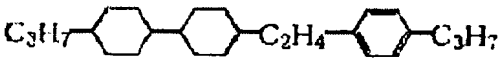
(1-0206)  6 wt%

(1-0207)  12 wt%

(1-0208)  12 wt%

(1-0209)  7 wt%

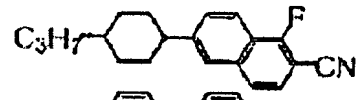
(1-0210)  7 wt%

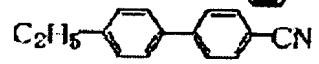
(1-0211)  8 wt%

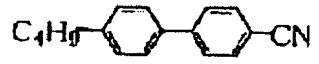
[0164]

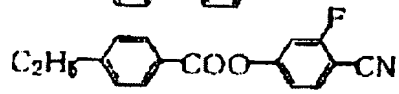
[Chemical Formula 45]

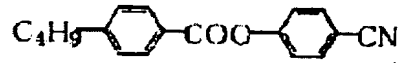
Examples of preferred composition: nematic liquid crystal composition (1-03)

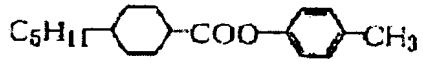
(1-0301)  17 wt%

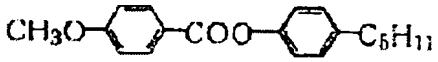
(1-0302)  12 wt%

(1-0303)  11 wt%

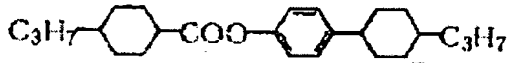
(1-0304)  5 wt%

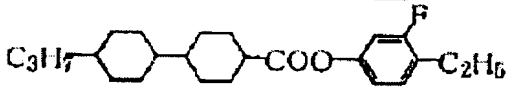
(1-0305)  10 wt%

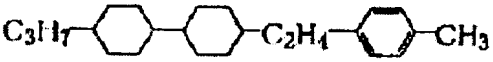
(1-0306)  10 wt%

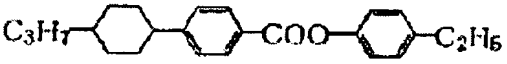
(1-0307)  7 wt%

(1-0308)  8 wt%

(1-0309)  5 wt%

(1-0310)  5 wt%

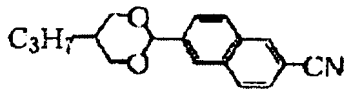
(1-0311)  5 wt%

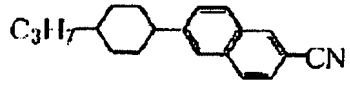
(1-0312)  5 wt%

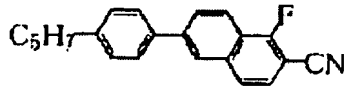
[0165]

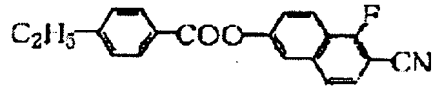
[Chemical Formula 46]

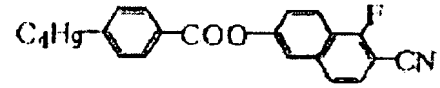
Examples of preferred composition: nematic liquid crystal composition (1-04)

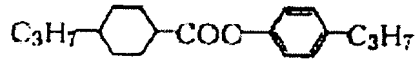
(1-0401)  5 wt%

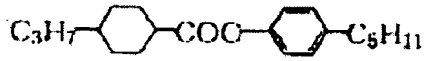
(1-0402)  5 wt%

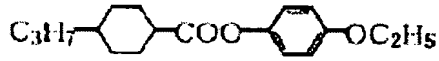
(1-0403)  12 wt%

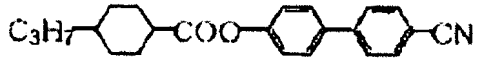
(1-0404)  8 wt%

(1-0405)  9 wt%

(1-0406)  12 wt%

(1-0407)  15 wt%

(1-0408)  13 wt%

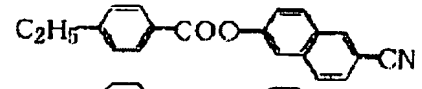
(1-0409)  18 wt%

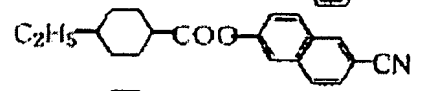
(1-0410)  3 wt%

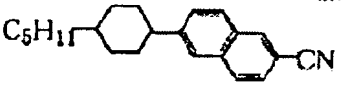
[0166]

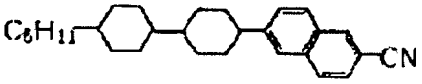
[Chemical Formula 47]

Examples of preferred composition: nematic liquid crystal composition (1-05)

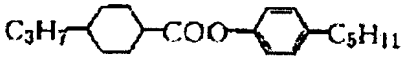
(1-0501)  10 wt %

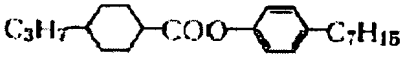
(1-0502)  5 wt %

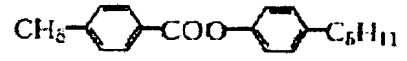
(1-0503)  10 wt %

(1-0504)  3 wt %

(1-0505)  15 wt %

(1-0506)  15 wt %

(1-0507)  15 wt %

(1-0508)  15 wt %

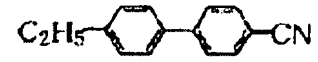
(1-0509)  7 wt %

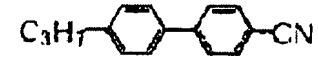
(1-0510)  5 wt %

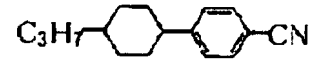
[0167]

[Chemical Formula 48]

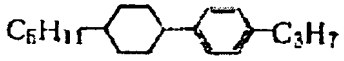
Examples of preferred composition: nematic liquid crystal composition (1-06)

(1-0601)  5 wt%

(1-0602)  5 wt%

(1-0603)  16 wt%

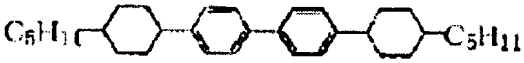
(1-0604)  16 wt%

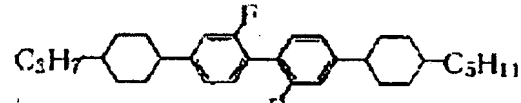
(1-0605)  17 wt%

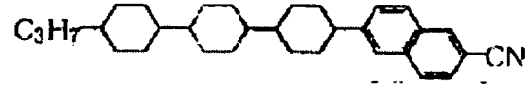
(1-0606)  12 wt%

(1-0607)  12 wt%

(1-0608)  6 wt%

(1-0609)  5 wt%

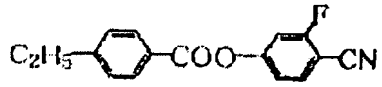
(1-0610)  3 wt%

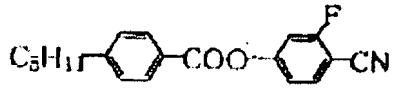
(1-0611)  3 wt%

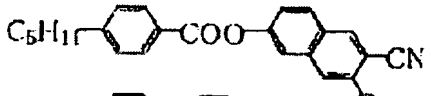
[0168]

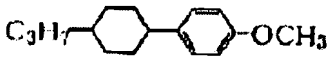
[Chemical Formula 49]

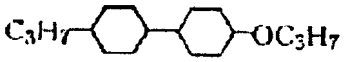
Examples of preferred composition: nematic liquid crystal composition (1-07)

(1-0701)  8 wt%

(1-0702)  10 wt%

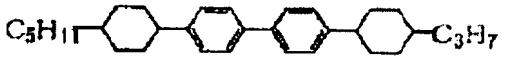
(1-0703)  7 wt%

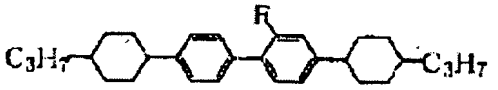
(1-0704)  12 wt%

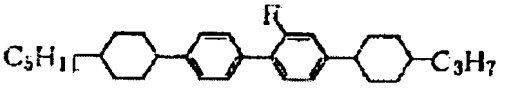
(1-0705)  18 wt%

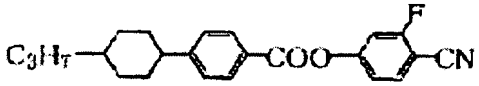
(1-0706)  10 wt%

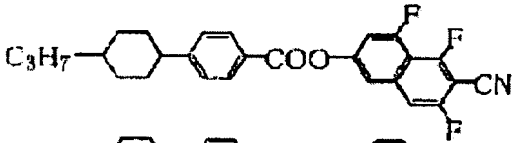
(1-0707)  5 wt%

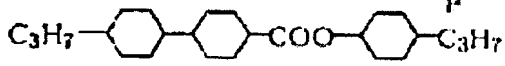
(1-0708)  5 wt%

(1-0709)  5 wt%

(1-0710)  5 wt%

(1-0711)  5 wt%

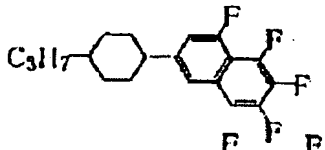
(1-0712)  5 wt%

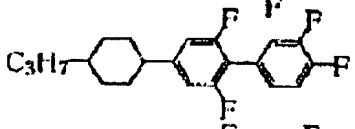
(1-0713)  5 wt%

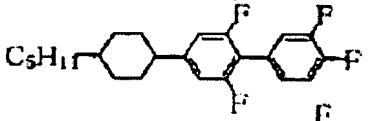
[0169]

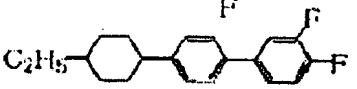
[Chemical Formula 50]

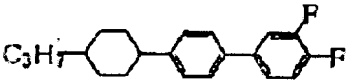
Examples of preferred composition: nematic liquid crystal composition (1-08)

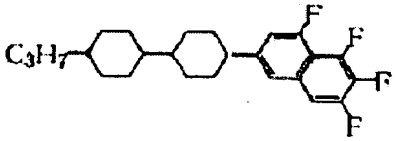
(1-0801)  7 wt%

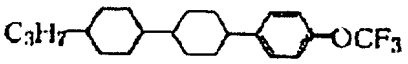
(1-0802)  4 wt%

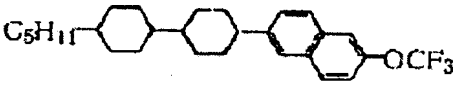
(1-0803)  4 wt%

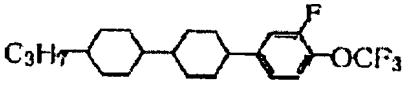
(1-0804)  7 wt%

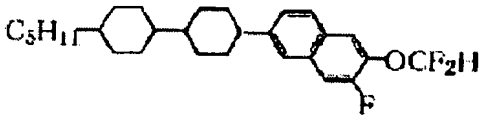
(1-0805)  8 wt%

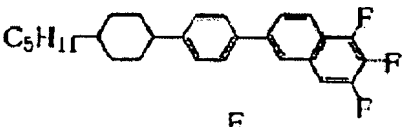
(1-0806)  13 wt%

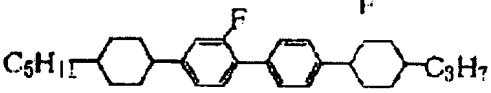
(1-0807)  4 wt%

(10-808)  4 wt%

(1-0809)  10 wt%

(1-0810)  12 wt%

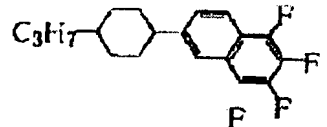
(1-0811)  20 wt%

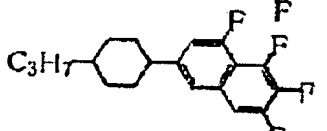
(1-0812)  7 wt%

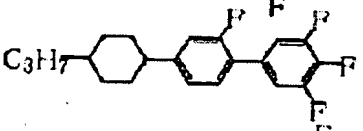
[0170]

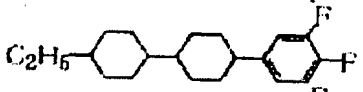
[Chemical Formula 51]

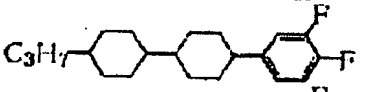
Examples of preferred composition: nematic liquid crystal composition (1-09)

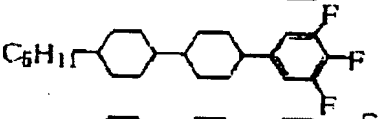
(1-0901)  7 wt %

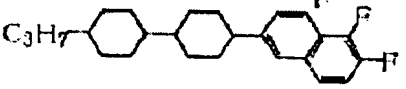
(1-0902)  7 wt %

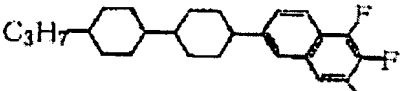
(1-0903)  4 wt %

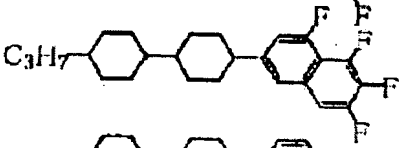
(1-0904)  7 wt %

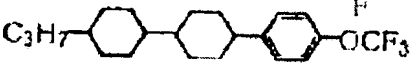
(1-0905)  8 wt %

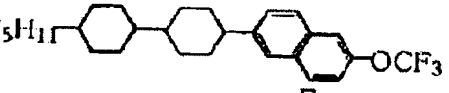
(1-0906)  4 wt %

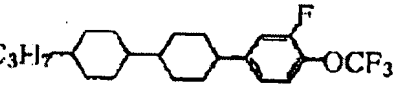
(1-0907)  7 wt %

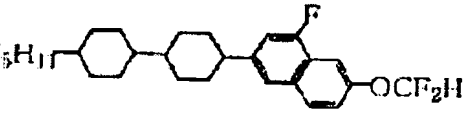
(1-0908)  13 wt %

(1-0909)  13 wt %

(1-0910)  4 wt %

(1-0911)  4 wt %

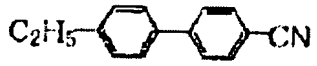
(1-0912)  10 wt %

(1-0913)  12 wt %

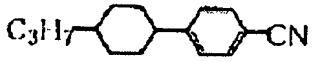
[0171]

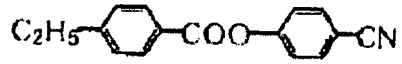
[Chemical Formula 52]

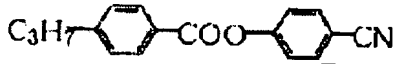
Examples of preferred composition: nematic liquid crystal composition (1-10)

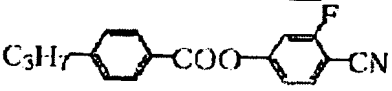
(1-1001)  12 wt%

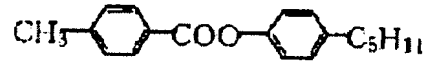
(1-1002)  12 wt%

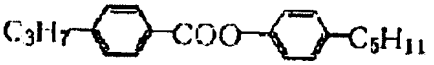
(1-1003)  18 wt%

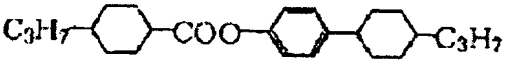
(1-1004)  6 wt%

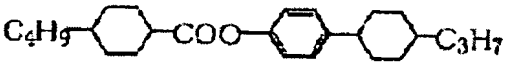
(1-1005)  6 wt%

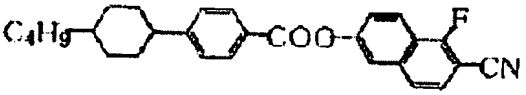
(1-1006)  5 wt%

(1-1007)  10 wt%

(1-1008)  12 wt%

(1-1009)  7 wt%

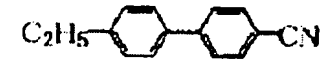
(1-1010)  7 wt%

(1-1011)  5 wt%

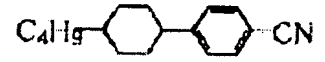
[0172]

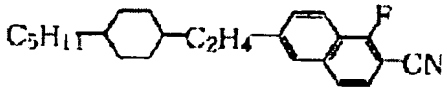
[Chemical Formula 53]

Examples of preferred composition: nematic liquid crystal composition (1-11)

(1-1101)  10 wt%

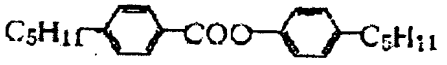
(1-1102)  10 wt%

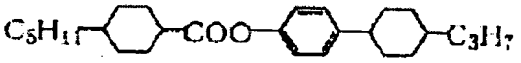
(1-1103)  10 wt%

(1-1104)  21 wt%

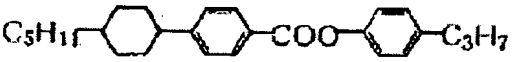
(1-1105)  13 wt%

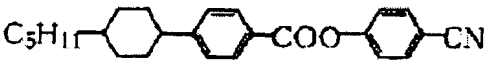
(1-1106)  12 wt%

(1-1107)  10 wt%

(1-1108)  3 wt%

(1-1109)  3 wt%

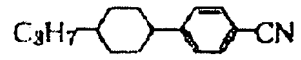
(1-1110)  5 wt%

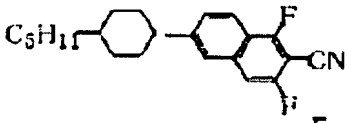
(1-1111)  3 wt%

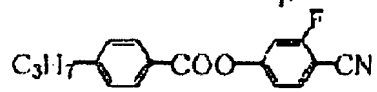
[0173]

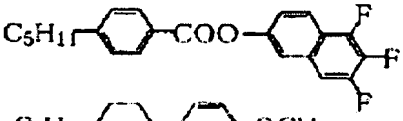
[Chemical Formula 54]

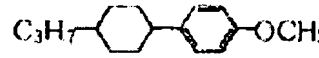
Examples of preferred composition: nematic liquid crystal composition (1-12)

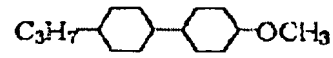
(1-1201)  8 wt%

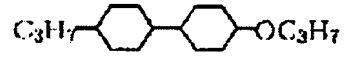
(1-1202)  6 wt%

(1-1203)  7 wt%

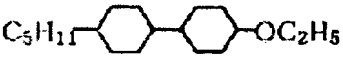
(1-1204)  10 wt%

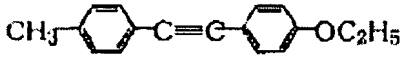
(1-1205)  11 wt%

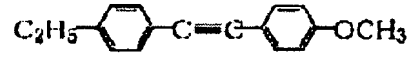
(1-1206)  10 wt%

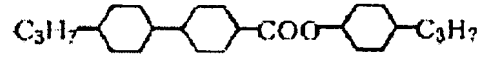
(1-1207)  10 wt%

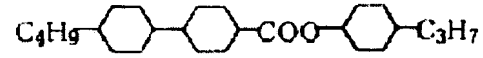
(1-1208)  10 wt%

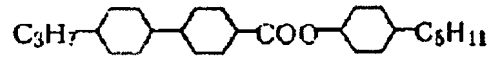
(1-1209)  9 wt%

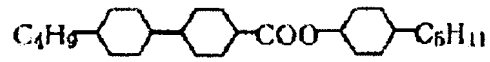
(1-1210)  3 wt%

(1-1211)  3 wt%

(1-1212)  4 wt%

(1-1213)  3 wt%

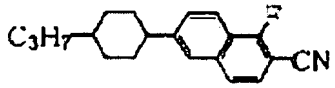
(1-1214)  3 wt%

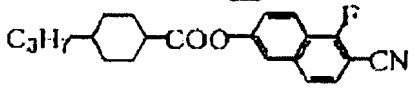
(1-1215)  3 wt%

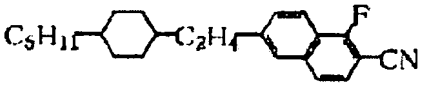
[0174]

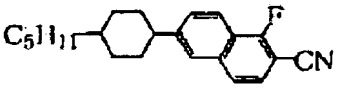
[Chemical Formula 55]

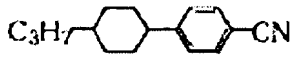
Examples of preferred composition: nematic liquid crystal composition (1-13)

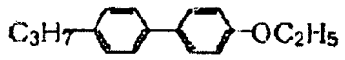
(1-1301)  5 wt %

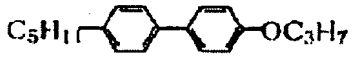
(1-1302)  15 wt %

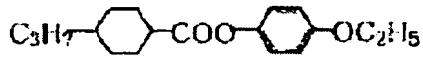
(1-1303)  10 wt %

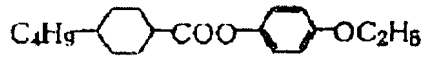
(1-1304)  13 wt %

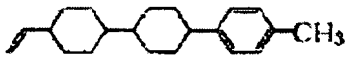
(1-1305)  7 wt %

(1-1306)  5 wt %

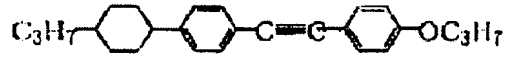
(1-1307)  5 wt %

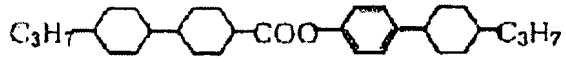
(1-1308)  6 wt %

(1-1309)  6 wt %

(1-1310)  7 wt %

(1-1311)  7 wt %

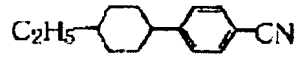
(1-1312)  7 wt %

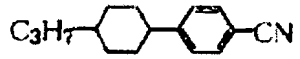
(1-1313)  7 wt %

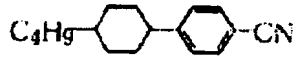
[0175]

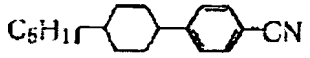
[Chemical Formula 56]

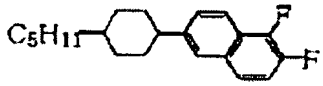
Examples of preferred composition: nematic liquid crystal composition (1-14)

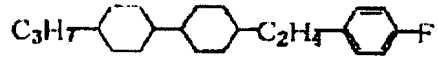
(1-1401)  7 wt%

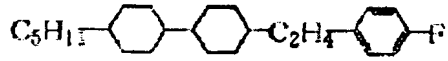
(1-1402)  17 wt%

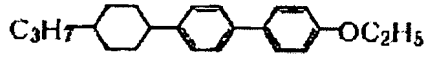
(1-1403)  14 wt%

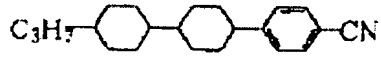
(1-1404)  15 wt%

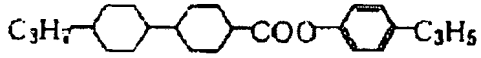
(1-1405)  7 wt%

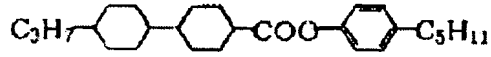
(1-1406)  7 wt%

(1-1407)  6 wt%

(1-1408)  11 wt%

(1-1409)  7 wt%

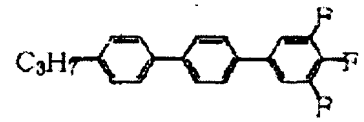
(1-1410)  5 wt%

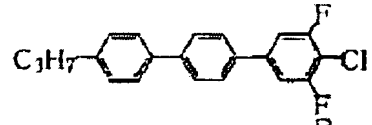
(1-1411)  4 wt%

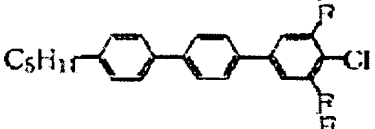
[0176]

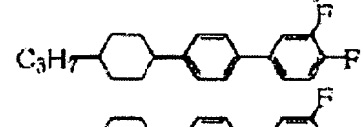
[Chemical Formula 57]

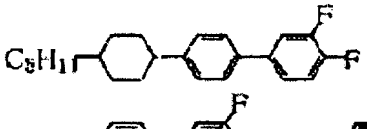
Examples of preferred composition: nematic liquid crystal composition (1-15)

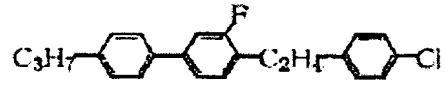
(1-1501)  10 wt %

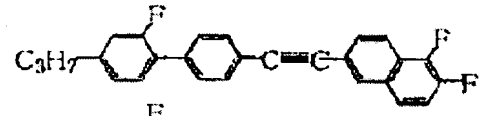
(1-1502)  10 wt %

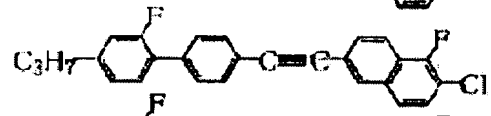
(1-1503)  12 wt %

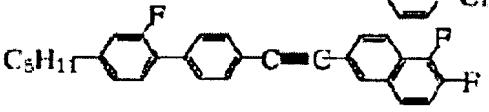
(1-1504)  10 wt %

(1-1505)  10 wt %

(1-1506)  16 wt %

(1-1507)  12 wt %

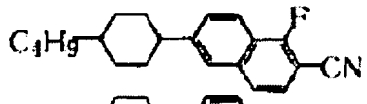
(1-1508)  10 wt %

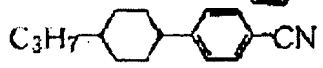
(1-1509)  10 wt %

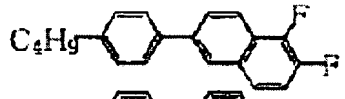
[0177]

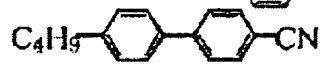
[Chemical Formula 58]

Examples of preferred composition: nematic liquid crystal composition (1-16)

(1-1601)  10 wt%

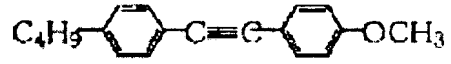
(1-1602)  16 wt%

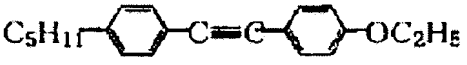
(1-1603)  7 wt%

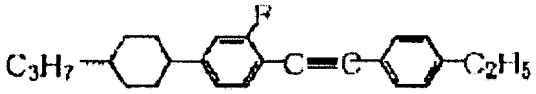
(1-1604)  7 wt%

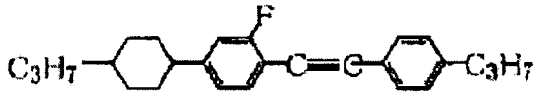
(1-1605)  8 wt%

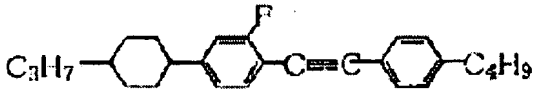
(1-1606)  5 wt%

(1-1607)  3 wt%

(1-1608)  5 wt%

(1-1609)  8 wt%

(1-1610)  8 wt%

(1-1611)  8 wt%

(1-1612)  5 wt%

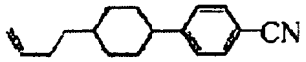
(1-1613)  5 wt%

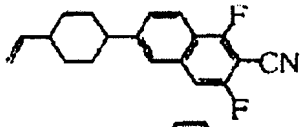
(1-1614)  5 wt%

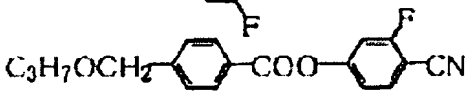
[0178]

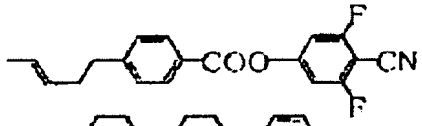
[Chemical Formula 59]

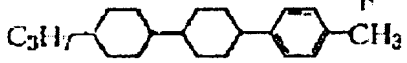
Examples of preferred composition: nematic liquid crystal composition (1-17)

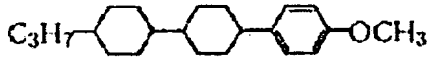
(1-1701)  12 wt%

(1-1702)  11 wt%

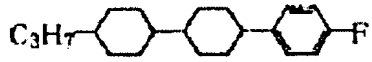
(1-1703)  14 wt%

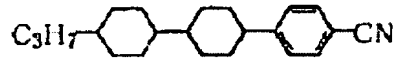
(1-1704)  11 wt%

(1-1705)  6 wt%

(1-1706)  5 wt%

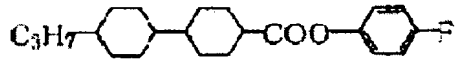
(1-1707)  5 wt%

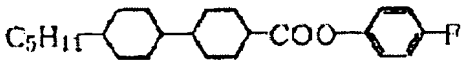
(1-1708)  5 wt%

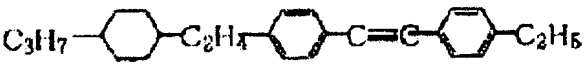
(1-1709)  5 wt%

(1-1710)  5 wt%

(1-1711)  5 wt%

(1-1712)  5 wt%

(1-1713)  5 wt%

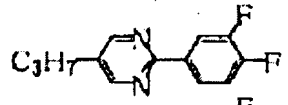
(1-1714)  3 wt%

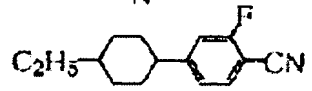
(1-1715)  3 wt%

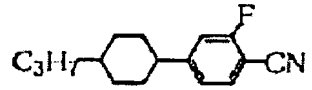
[0179]

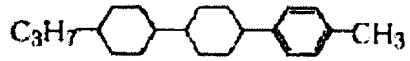
[Chemical Formula 60]

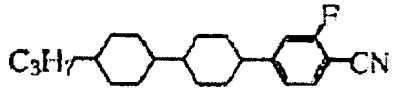
Examples of preferred composition: nematic liquid crystal composition (1-18)

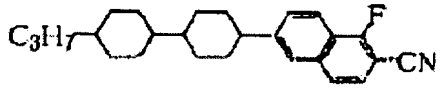
(1-1801)  13 wt%

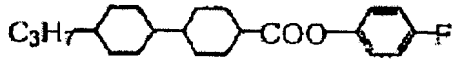
(1-1802)  16 wt%

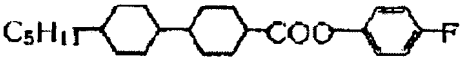
(1-1803)  4 wt%

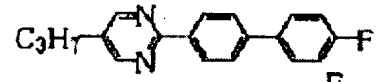
(1-1804)  7 wt%

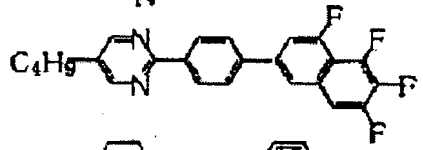
(1-1805)  12 wt%

(1-1806)  12 wt%

(1-1807)  5 wt%

(1-1808)  5 wt%

(1-1809)  7 wt%

(1-1810)  7 wt%

(1-1811)  4 wt%

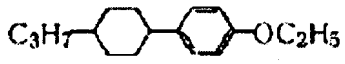
(1-1812)  4 wt%

(1-1813)  4 wt%

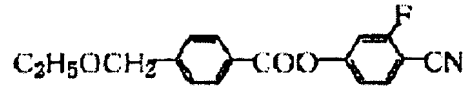
[0180]

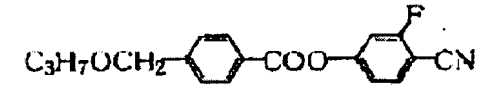
[Chemical Formula 61]

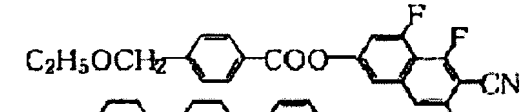
Examples of preferred composition: nematic liquid crystal composition (1-19)

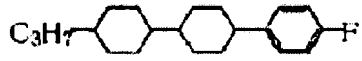
(1-1901)  9 wt%

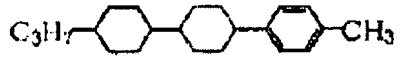
(1-1902)  4 wt%

(1-1903)  1 wt%

(1-1904)  5 wt%

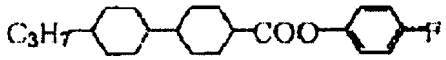
(1-1905)  8 wt%

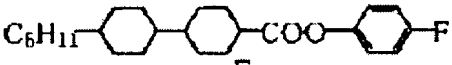
(1-1906)  5 wt%

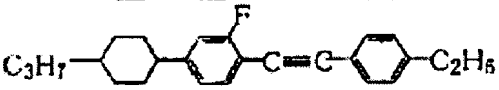
(1-1907)  21 wt%

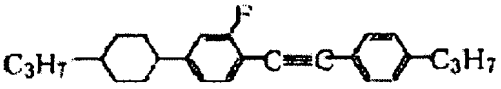
(1-1908)  2 wt%

(1-1909)  6 wt%

(1-1910)  5 wt%

(1-1911)  5 wt%

(1-1912)  6 wt%

(1-1913)  5 wt%

(1-1914)  5 wt%

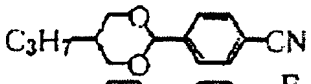
(1-1915)  5 wt%

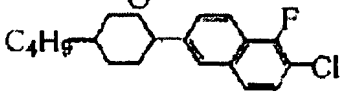
(1-1916)  5 wt%

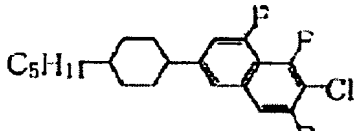
[0181]

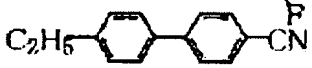
[Chemical Formula 62]

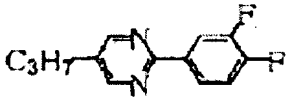
Examples of preferred composition: nematic liquid crystal composition (1-20)

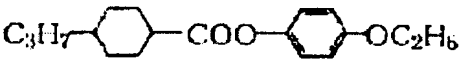
(1-2001)  14 wt%

(1-2002)  16 wt%

(1-2003)  11 wt%

(1-2004)  10 wt%

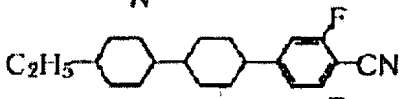
(1-2005)  5 wt%

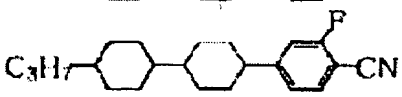
(1-2006)  5 wt%

(1-2007)  5 wt%

(1-2008)  7 wt%

(1-2009)  7 wt%

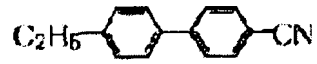
(1-2010)  10 wt%

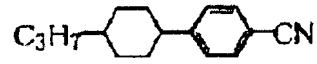
(1-2011)  10 wt%

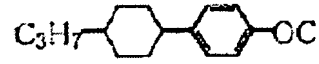
[0182]

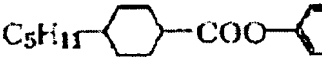
[Chemical Formula 63]

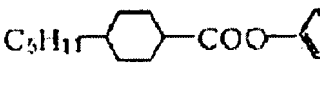
Examples of preferred composition: nematic liquid crystal composition (1-21)

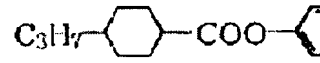
(1-2101)  12 wt %

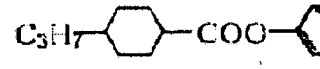
(1-2102)  12 wt %

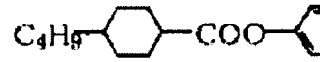
(1-2103)  9 wt %

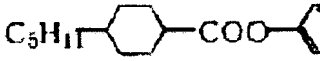
(1-2104)  8 wt %

(1-2105)  9 wt %

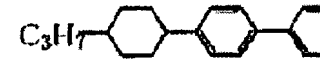
(1-2106)  5 wt %

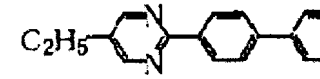
(1-2107)  5 wt %

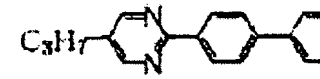
(1-2108)  5 wt %

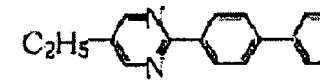
(1-2109)  5 wt %

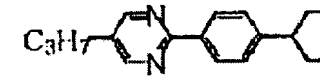
(1-2110)  6 wt %

(1-2111)  5 wt %

(1-2112)  4 wt %

(1-2113)  5 wt %

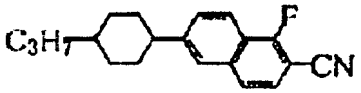
(1-2114)  5 wt %

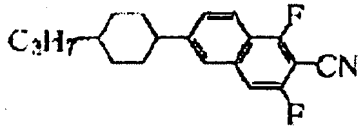
(1-2115)  5 wt %

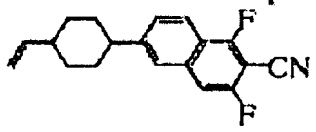
[0183]

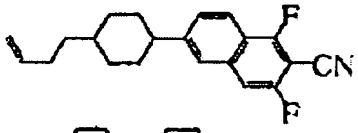
[Chemical Formula 64]

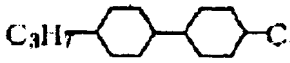
Examples of preferred composition: nematic liquid crystal composition (1-22)

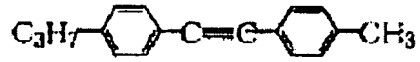
(1-2201)  15 wt %

(1-2202)  10 wt %

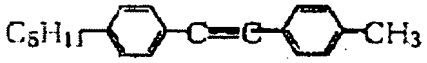
(1-2203)  10 wt %

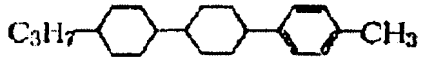
(1-2204)  10 wt %

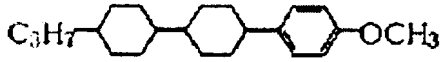
(1-2205)  7 wt %

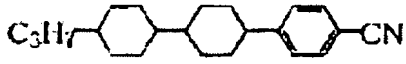
(1-2206)  14 wt %

(1-2207)  13 wt %

(1-2208)  5 wt %

(1-2209)  4 wt %

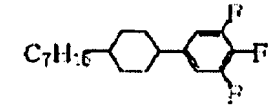
(1-2210)  4 wt %

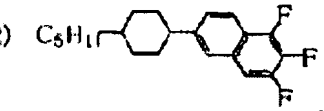
(1-2211)  8 wt %

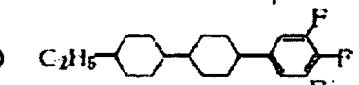
[0184]

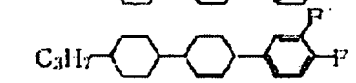
[Chemical Formula 65]

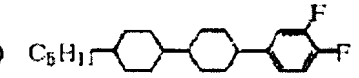
Examples of preferred composition: nematic liquid crystal composition (1-23)

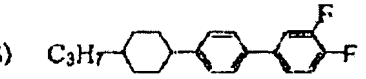
(1-2301)  3 wt%

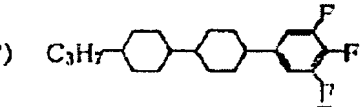
(1-2302)  11 wt%

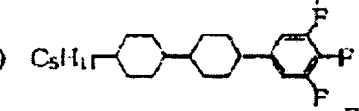
(1-2303)  6 wt%

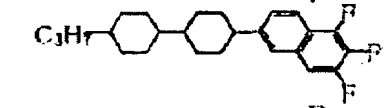
(1-2304)  7 wt%

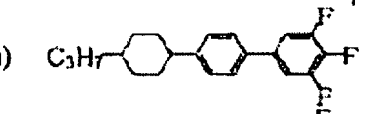
(1-2305)  7 wt%

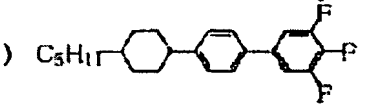
(1-2306)  4 wt%

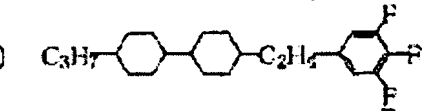
(1-2307)  9 wt%

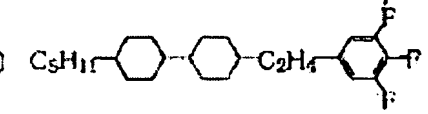
(1-2308)  9 wt%

(1-2309)  10 wt%

(1-2310)  10 wt%

(1-2311)  7 wt%

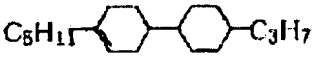
(1-2312)  9 wt%

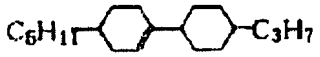
(1-2313)  8 wt%

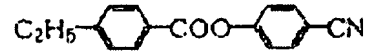
[0185]

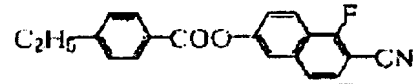
[Chemical Formula 66]

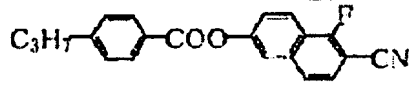
Examples of preferred composition: nematic liquid crystal composition (1-24)

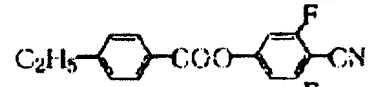
(1-2401)  4 wt%

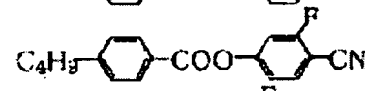
(1-2402)  3 wt%

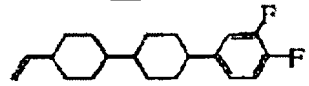
(1-2403)  3 wt%

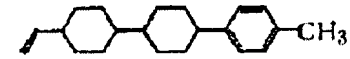
(1-2404)  3 wt%

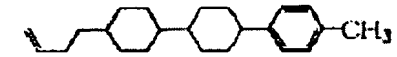
(1-2405)  3 wt%

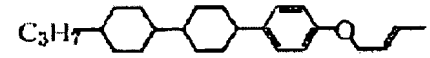
(1-2406)  3 wt%

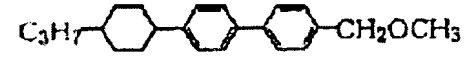
(1-2407)  4 wt%

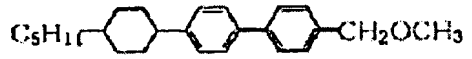
(1-2408)  18 wt%

(1-2409)  17 wt%

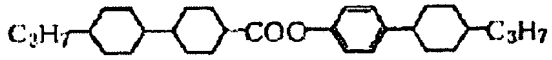
(1-2410)  17 wt%

(1-2411)  4 wt%

(1-2412)  7 wt%

(1-2413)  4 wt%

(1-2414)  5 wt%

(1-2415)  5 wt%

The market of the liquid crystal display device is in the state of fierce price competition. To survive this competition, the liquid crystal material is required to be capable of easily optimize the display characteristics for various applications. Thus such systematized liquid crystal

materials 2-bottle type composed of two kinds of liquid crystal material or 4-bottle type composed of four kinds of liquid crystal material. Representative characteristics thereof include the threshold voltage, the birefringent index and the nematic phase-isotropic liquid phase transition temperature. For example, when such a 2-bottle system is used that consists of a liquid crystal material having a higher threshold voltage and a liquid crystal material having a lower threshold voltage, which are identical with regards to other characteristics, requirements can be met more quickly at a lower cost by combining two kinds of liquid crystal materials in a proper proportion without restriction of the electronics components used in the drive circuit. The present invention is useful for this purpose, too, and allows it to use a mixture of the nematic liquid crystal compositions (1-01) to (1-24) and compositions obtained by substituting a part thereof. Such an application may be carried out, as a matter of course, including Examples to be described later.

[0186]

[EXAMPLES]

The present invention will now be described in detail below by way of Examples, although it should be understood that the present invention is not limited to these Examples. In the following description of compositions of the Examples, "percentages" are by weight unless otherwise specified.

[0187]

Physical properties of the liquid crystal composition and

the display characteristics of the liquid crystal display device that employs the TN-LCD of the Examples are as follows.

T_{N-I}: Nematic phase-isotropic liquid phase transition temperature (°C)

T_{-N}: Solid phase or smectic phase-nematic phase transition temperature (°C)

Vth: Threshold voltage (V) at 20°C when TN-LCD having cell thickness 6 μm is constituted

γ: Ratio of saturation voltage (Vsat) and Vth, namely sharpness at 20°C

$\Delta\varepsilon$: Dielectric constant anisotropy at 20°C

Δn: Birefringent index at 20°C

$\tau r=\tau d$: Period of time when the rise time τr if a predetermined voltage is applied starting from 0V and the decay time τd if the voltage is decreased from the predetermined voltage to zero equal to each other, at 20°C

η: Viscosity at 20°C (cp)

The liquid crystal display device having the STN-LCD display characteristics was made as follows. A chiral material S-811 (manufactured by Merc) was added to the liquid crystal composition, thereby preparing a mixed liquid crystal. An alignment film was formed by rubbing an organic film of Sun-Ever 610 (manufactured by Nissan Chemical Industries, Ltd.) onto an opposing planar transparent electrode, thereby to make STN-LCD display cell having a twist angle of 240 degrees. The mixed liquid crystal was poured into the cell, thereby to make the liquid crystal display device. The chiral

material was added to the liquid crystal composition in such a proportion that the intrinsic helical pitch P of the mixed liquid crystal and the thickness d of the display cell satisfy the relations $\Delta n \cdot d=0.85$ and $d/P=0.50$. Threshold voltage, sharpness, temperature dependence of the driving voltage and response speed of this mixed liquid crystal were measured.

[0188]

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth: Threshold voltage (V) at 20°C

γ: Ratio of saturation voltage (Vsat) and Vth, namely sharpness at 20°C

τr=τd: Response time when driven with duty ratio of 1/240

Δ(Vth)/Δ(T): Temperature dependence of the driving voltage

Chemical stability of the composition was checked by heating acceleration test wherein an ampoule filled with 2 grams of the liquid crystal composition was subjected to substitution with nitrogen after evacuating the inside, before undergoing the test at 150°C for one hour. Resistivity before the heating acceleration test, resistivity after heating acceleration test, voltage holding ratio before heating acceleration test and voltage holding ratio after heating acceleration test of the liquid crystal composition were measured.

[0189]

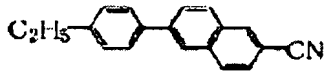
One or plural kinds of compounds described in the Examples can be used in place of compounds represented by the

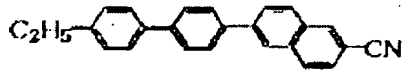
general formulas (I-1) to (III-4) according to the desired purposes and applications. Specific compounds are represented by the form of the following examples.

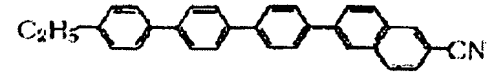
[Chemical Formula 67]

Definition of compounds

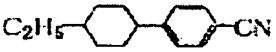
Liquid crystal component A

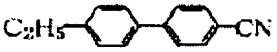
(2-11) 

(2-12) 

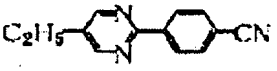
(2-13) 

Liquid crystal component B

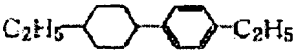
(2-21) 

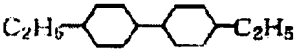
(2-22) 

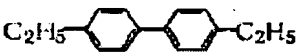
(2-23) 

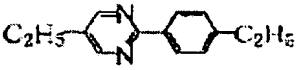
(2-24) 

Liquid crystal component C

(2-31) 

(2-32) 

(2-33) 

(2-34) 

Liquid crystal component A

Examples of the general formula (I-1)

Compound (2-11): side chain group (I-4a), basic structure (I-1a), and polar group (I-5a)

Examples of the general formula (I-2)

Compound (2-12): side chain group (I-4a), basic structure (I-2a), and polar group (I-5a)

Examples of the general formula (I-3)

Compound (2-13): side chain group (I-4a), basic structure (I-3a), and polar group (I-5a)

Liquid crystal component B

Examples of the general formula (II-1)

Compound (2-21): side chain group (II-5a), basic structure (II-1a), and polar group (II-6a)

Examples of the general formula (II-2)

Compound (2-22): side chain group (II-5a), basic structure (II-2a), and polar group (II-6a)

Examples of the general formula (II-3)

Compound (2-23): side chain group (II-5a), basic structure (II-3a), and polar group (II-6a)

Examples of the general formula (II-4)

Compound (2-24): side chain group (II-5a), basic structure (II-4a), and polar group (II-6a)

Liquid crystal component C

Examples of the general formula (III-1)

Compound (2-31): side chain group (III-5b), basic structure (III-1a), and polar group (III-5b)

Examples of the general formula (III-2)

Compound (2-32): side chain group (III-5b), basic structure (III-2a), and polar group (III-5b)

Examples of the general formula (III-3)

Compound (2-33): side chain group (III-5b), basic structure (III-3a), and polar group (III-5b)

Examples of the general formula (III-4)

Compound (2-34): side chain group (III-5b), basic structure (III-4a), and polar group (III-5b)

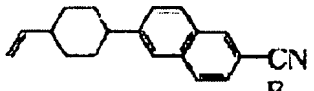
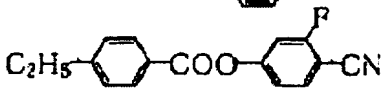
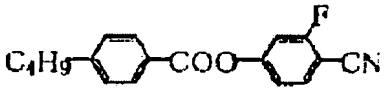
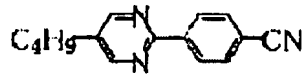
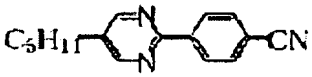
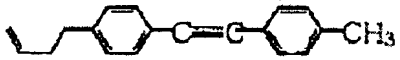
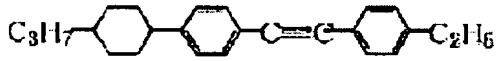
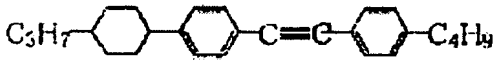
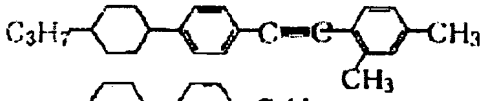
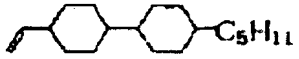
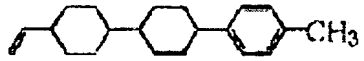
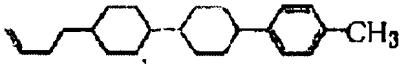
(Example 1)

A nematic liquid crystal composition (3-01) was prepared from

[0191]

[Chemical Formula 68]

Nematic liquid crystal composition (3-01)

(3-0101)		7 wt %
(3-0102)		4 wt %
(3-0103)		6 wt %
(3-0104)		3 wt %
(3-0105)		3 wt %
(3-0106)		11 wt %
(3-0107)		8 wt %
(3-0108)		8 wt %
(3-0109)		11 wt %
(3-0110)		10 wt %
(3-0111)		10 wt %
(3-0112)		11 wt %
(3-0113)		8 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 104.1°C

T_{-N} : -50. °C

Vth : 2.06 V

Y : 1.15

$\Delta\varepsilon$: 8.3

Δn : 0.168

η : 17.9 c.p.

The chiral material S-811 (manufactured by Merck) was added to this nematic liquid crystal composition, thereby preparing a mixed liquid crystal. An alignment film was formed by rubbing an organic film of Sun-Ever 610 (manufactured by Nissan Chemical Industries, Ltd.) onto an opposing planar transparent electrode, thereby to make STN-LCD display cell having a twist angle of 240 degrees. The mixed liquid crystal prepared as described above was poured into the cell, thereby to make a liquid crystal display device. Measurement of the display characteristics showed that the liquid crystal display device having temperature dependence of the driving voltage as low as 2.0 mV/°C and STN-LCD display characteristics of excellent high-frequency time division characteristic was obtained. The chiral material was added to the liquid crystal composition in such a proportion that the intrinsic helical pitch P of the liquid crystal mixture and the thickness d of the display cell satisfy the relations $\Delta n \cdot d=0.85$ and $d/P=0.50$. The STN-LCD was made in the same manner as described above.

[0192]

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.31 V

γ : 1.030

$\Delta(Vth)/\Delta(T)$: 2.0 mV/°C (T=5 to 40°C)

$\tau r=\tau d$: 103. msec. (When driven with duty ratio of 1/240)

The nematic liquid crystal composition (3-0101) of Example 1 was replaced by a compound: side chain group (I-4a), basic structure (I-1j) and polar group (I-5a) to prepare a nematic liquid crystal composition (3-01-01).

[0193]

The nematic liquid crystal composition (3-0101) of Example 1 was replaced by a compound: side chain group (I-4c), basic structure (I-1j) and polar group (I-5a) to prepare a nematic liquid crystal composition (3-01-02).

[0194]

The nematic liquid crystal composition (3-0101) of Example 1 was replaced by a compound: side chain group (I-4h), basic structure (I-1j) and polar group (I-5a) to prepare a nematic liquid crystal composition (3-01-03).

[0195]

The nematic liquid crystal composition (3-0101) of Example 1 was replaced by a compound: side chain group (I-4s), basic structure (I-1j) and polar group (I-5a) to prepare a nematic liquid crystal composition (3-01-04).

[0196]

The nematic liquid crystal composition (3-0101) of Example 1 was replaced by a compound: side chain group (I-4ai), basic structure (I-1j) and polar group (I-5a) to prepare a nematic liquid crystal composition (3-01-05).

[0197]

Using these nematic liquid crystal compositions (3-01-01) to (3-01-05), display characteristics were measured in the same manner as in Example 1. As a result, the display characteristics of these nematic liquid crystal compositions showed good results, similar to Example 1.

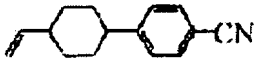
(Example 2)

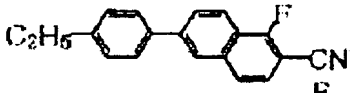
A nematic liquid crystal composition (3-02) was prepared from

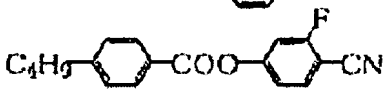
[0198]

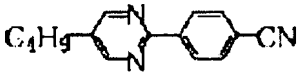
[Chemical Formula 69]

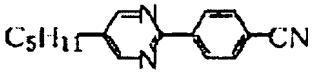
Nematic liquid crystal composition (3-02)

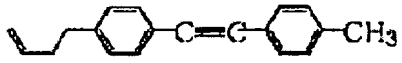
(3-0201)  7 wt %

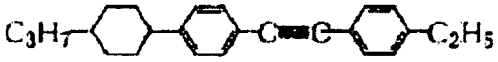
(3-0202)  4 wt %

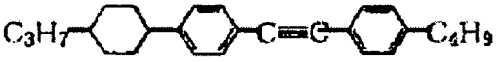
(3-0203)  6 wt %

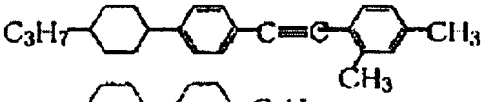
(3-0204)  3 wt %

(3-0205)  3 wt %

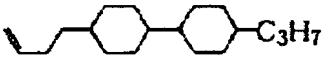
(3-0206)  11 wt %

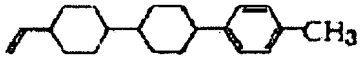
(3-0207)  8 wt %

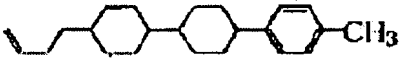
(3-0208)  8 wt %

(3-0209)  11 wt %

(3-0210)  10 wt %

(3-0211)  10 wt %

(3-0212)  11 wt %

(3-0213)  8 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 104.9°C

T_{-N} : -50. °C

Vth : 2.09 V

γ : 1.15

Δε : 7.6

Δn : 0.168

η : 17.0 c.p.

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.31 V

γ : 1.029

Δ(Vth)/Δ(T) : 2.0 mV/°C (T=5 to 40°C)

τr=τd : 101. msec. (When driven with duty ratio of 1/240)

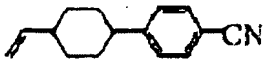
(Comparative Example 1)

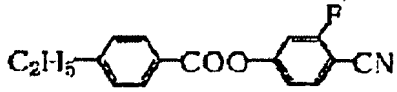
In order to demonstrate the superiority of the present invention, a mixed liquid crystal (b-01) was made by substituting the liquid crystal component A of the nematic liquid crystal composition (3-02) described above with another compound. Specifically, the compound (3-0202) was replaced by a compound represented by formula (b-0102) having excellent effects of decreasing the driving voltage and improving the temperature dependence of the driving voltage.

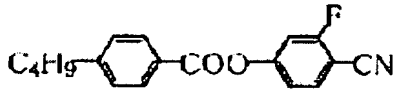
[0199]

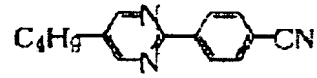
[Chemical Formula 70]

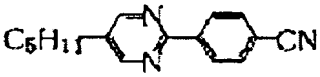
Comparative liquid crystal (b-01)

(b-0101)  7 wt%

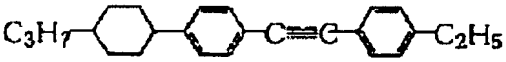
(b-0102)  4 wt%

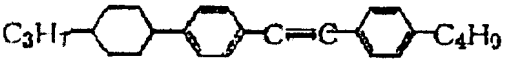
(b-0103)  6 wt%

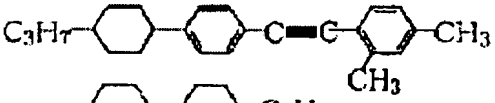
(b-0104)  3 wt%

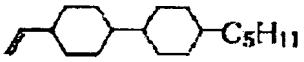
(b-0105)  3 wt%

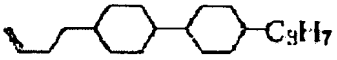
(b-0106)  11 wt%

(b-0107)  8 wt%

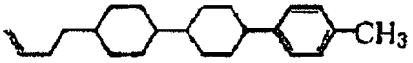
(b-0108)  8 wt%

(b-0109)  11 wt%

(b-0110)  10 wt%

(b-0111)  10 wt%

(b-0112)  11 wt%

(b-0113)  8 wt%

Various properties of this composition were measured. The results are as follows.

T_{N-I} : 100.7°C

T_{-N} : -50. °C

Vth : 2.08 V

$\Delta\varepsilon$: 8.1

Δn : 0.165

η : 17.7 c.p.

In the same manner as in the case of the nematic liquid crystal composition (3-02), STN-LCD using the mixed liquid crystal (b-01) was prepared.

[0200]

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.31V

γ : 1.039

$\Delta(Vth)/\Delta(T)$: 2.8 mV/°C (T=5 to 40°C)

$\tau r=\tau d$: 138. msec. (When driven with duty ratio of 1/240)

As is apparent from comparison between the characteristics, the liquid crystal composition of the present invention reduces the temperature dependency of the threshold voltage by about 30% due to the liquid crystal component A in a small amount such as 4%, and also reduces the response speed by about 40%. The nematic liquid crystal composition of the present invention exhibited more improved effects compared to comparative liquid crystals.

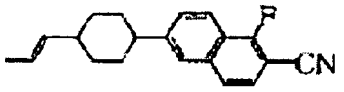
(Example 3)

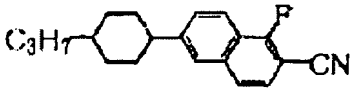
A nematic liquid crystal composition (3-03) was prepared from

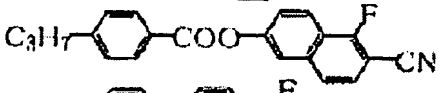
[0201]

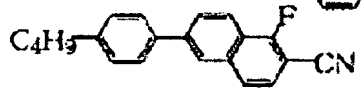
[Chemical Formula 71]

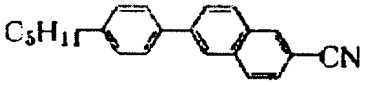
Nematic liquid crystal composition (3-03)

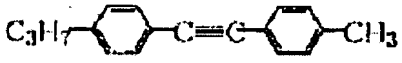
(3-0301)  10 wt %

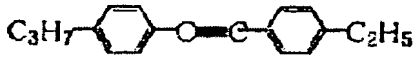
(3-0302)  5 wt %

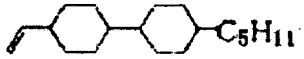
(3-0303)  5 wt %

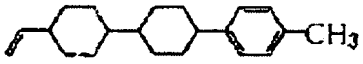
(3-0304)  5 wt %

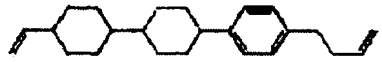
(3-0305)  5 wt %

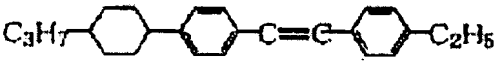
(3-0306)  10 wt %

(3-0307)  10 wt %

(3-0308)  20 wt %

(3-0309)  13 wt %

(3-0310)  7 wt %

(3-0311)  5 wt %

(3-0312)  5 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 101.0°C

T_{-N} : -70. °C

Vth : 1.93 V

γ : 1.16

Δε : 8.5

Δn : 0.179

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.12 V

γ : 1.028

Δ(Vth)/Δ(T) : 2.1 mV/°C (T=5 to 40°C)

The nematic liquid crystal composition (3-0303) of Example 3 was replaced by a compound: side chain group (I-4b), basic structure (I-1e) and polar group (I-5b) to prepare a nematic liquid crystal composition (3-03-01).

[0202]

The nematic liquid crystal composition (3-0303) of Example 3 was replaced by a compound: side chain group (I-4b), basic structure (I-1f) and polar group (I-5b) to prepare a nematic liquid crystal composition (3-03-02).

[0203]

The nematic liquid crystal composition (3-0303) of Example 3 was replaced by a compound: side chain group (I-4b), basic structure (I-1d) and polar group (I-5c) to prepare a nematic liquid crystal composition (3-0-03).

[0204]

The nematic liquid crystal composition (3-0303) of Example 3 was replaced by a compound: side chain group (I-4b), basic structure (I-1d) and polar group (I-5d) to prepare a nematic liquid crystal composition (3-03-04).

[0205]

The nematic liquid crystal composition (3-0303) of Example 3 was replaced by a compound: side chain group (I-4b), basic structure (I-1d) and polar group (I-5e) to prepare a nematic liquid crystal composition (3-03-05).

[0206]

Using these nematic liquid crystal compositions (3-03-01) to (3-03-05), display characteristics were measured in the same manner as in Example 3. As a result, the display characteristics of these nematic liquid crystal compositions showed good results, similar to Example 3.

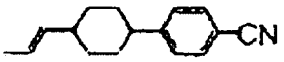
(Example 4)

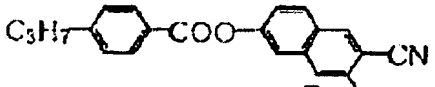
A nematic liquid crystal composition (3-04) was prepared from

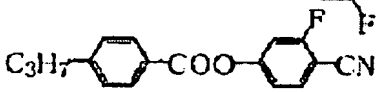
[0207]

[Chemical Formula 72]

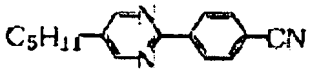
Nematic liquid crystal composition (3-04)

(3-0401)  10 wt%

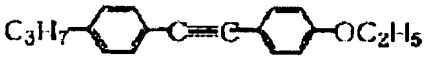
(3-0402)  5 wt%

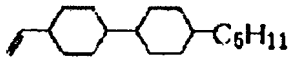
(3-0403)  5 wt%

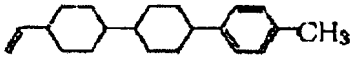
(3-0404)  5 wt%

(3-0405)  5 wt%

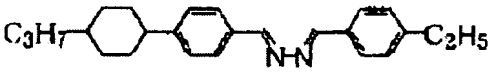
(3-0406)  5 wt%

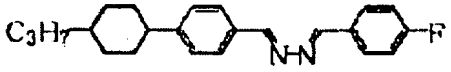
(3-0407)  10 wt%

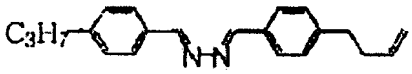
(3-0408)  15 wt%

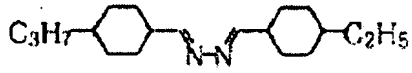
(3-0409)  13 wt%

(3-0410)  7 wt%

(3-0411)  5 wt%

(3-0412)  5 wt%

(3-0413)  5 wt%

(3-0414)  5 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 90.8°C

T_{-N} : -70. °C

Vth : 2.10 V

γ : 1.15

Δε : 7.3

Δn : 0.167

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.35 V

γ : 1.028

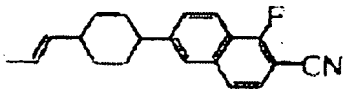
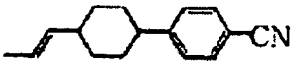
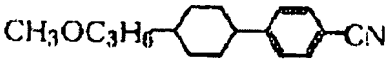
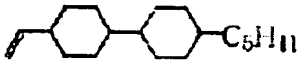
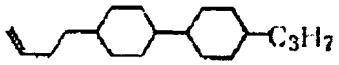
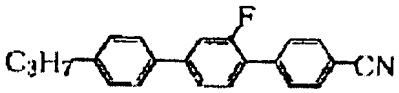
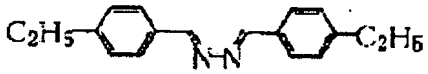
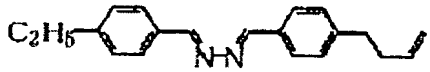
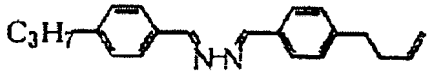
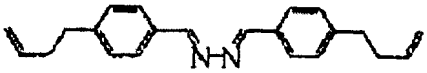
(Example 5)

A nematic liquid crystal composition (3-05) was prepared from

[0208]

[Chemical Formula 73]

Nematic liquid crystal composition (3-05)

(3-0501)		12 wt%
(3-0502)		11 wt%
(3-0503)		7 wt%
(3-0504)		18 wt%
(3-0505)		18 wt%
(3-0506)		7 wt%
(3-0507)		6 wt%
(3-0508)		3 wt%
(3-0509)		6 wt%
(3-0510)		3 wt%
(3-0511)		3 wt%
(3-0512)		6 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 89.8°C

T_{-N} : -31. °C

Vth : 1.80 V

Y : 1.13

Δε : 7.9

Δn : 0.176

This nematic liquid crystal composition shows a value of optical sharpness near 1.12 that is the limit of TN-LCD liquid crystal shown in the literature "High-speed Liquid Crystal Technology" (p.63, CMC Publication). Thus it can be understood that this liquid crystal composition is useful for high-frequency multiplexing drive.

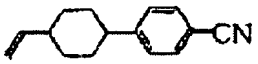
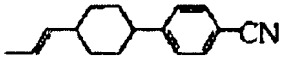
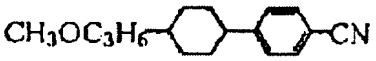
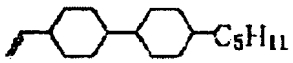
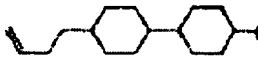
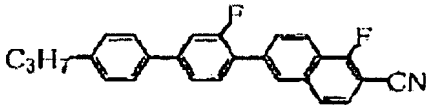
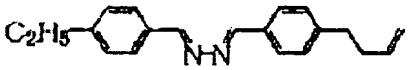
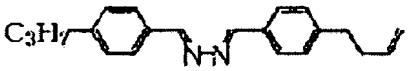
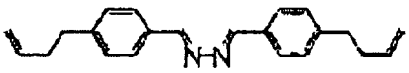
(Example 6)

A nematic liquid crystal composition (3-06) was prepared from

[0209]

[Chemical Formula 74]

Nematic liquid crystal composition (3-06)

(3-0601)		12 wt%
(3-0602)		11 wt%
(3-0603)		7 wt %
(3-0604)		18 wt%
(3-0605)		18 wt %
(3-0606)		7 wt %
(3-0607)		6 wt %
(3-0608)		3 wt %
(3-0609)		6 wt %
(3-0610)		3 wt%
(3-0611)		3 wt %
(3-0612)		6 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 89.1°C

T_{-N} : -32. °C

Δn : 0.181

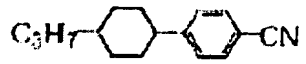
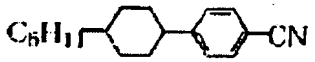
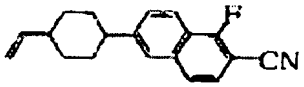
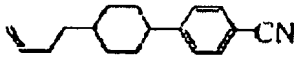
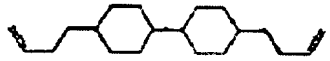
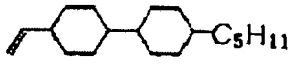
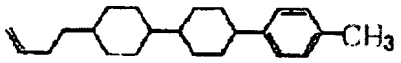
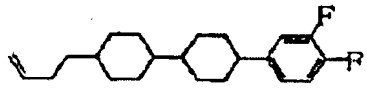
(Example 7)

A nematic liquid crystal composition (3-07) was prepared from

[0210]

[Chemical Formula 75]

Nematic liquid crystal composition (3-07)

(3-0701)		7 wt%
(3-0702)		8 wt%
(3-0703)		10 wt%
(3-0704)		10 wt%
(3-0705)		20 wt%
(3-0706)		10 wt%
(3-0707)		10 wt%
(3-0708)		10 wt%
(3-0709)		5 wt%
(3-0710)		10 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 77.3°C

T_{-N} : -40. °C

Vth : 1.78 V

Y : 1.13

Δε : 6.5

Δn : 0.090

τr=τd : 16.1 msec.

η : 14.9 c.p.

This nematic liquid crystal composition shows a value of optical sharpness near 1.12 that is the limit of TN-LCD liquid crystal shown in the literature "High-speed Liquid Crystal Technology" (p.63, CMC Publication). Thus it can be understood that this liquid crystal composition is useful for high-frequency multiplexing drive.

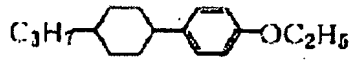
(Example 8)

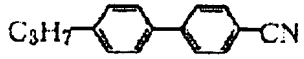
A nematic liquid crystal composition (3-08) was prepared from

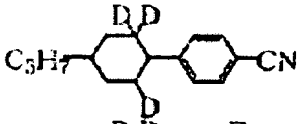
[0211]

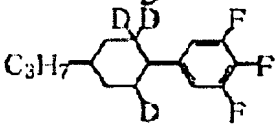
[Chemical Formula 76]

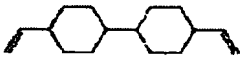
Nematic liquid crystal composition (3-08)

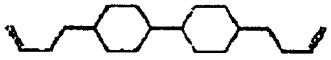
(3-0801)  7 wt %

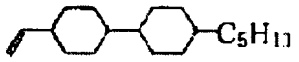
(3-0802)  7 wt %

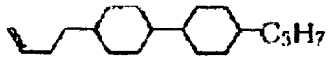
(3-0803)  13 wt %

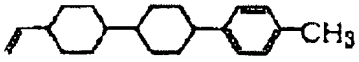
(3-0804)  7 wt %

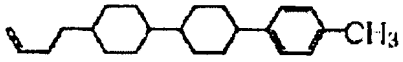
(3-0805)  3 wt %

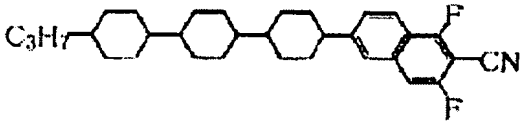
(3-0806)  15 wt %

(3-0807)  10 wt %

(3-0808)  10 wt %

(3-0809)  14 wt %

(3-0810)  12 wt %

(3-0811)  2 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 76.2°C

T_{-N} : -31. °C

Vth : 2.20 V

$\Delta\varepsilon$: 4.4

Δn : 0.092

$\tau r = \tau d$: 14.6 msec.

η : 11.3 c.p.

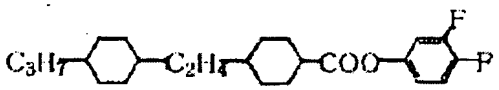
(Example 9)

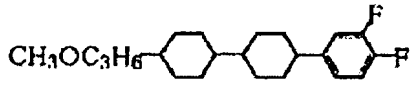
A nematic liquid crystal composition (3-09) was prepared from

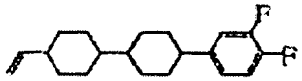
[0212]

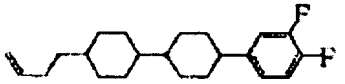
[Chemical Formula 77]

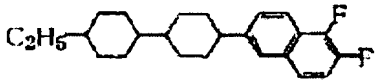
Nematic liquid crystal composition (3-09)

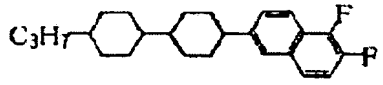
(3-0901)  10 wt%

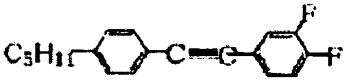
(3-0902)  7 wt%

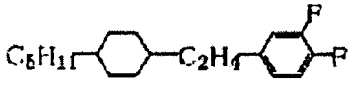
(3-0903)  15 wt%

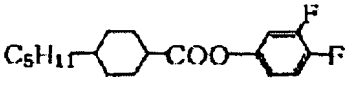
(3-0904)  15 wt%

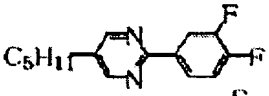
(3-0905)  5 wt%

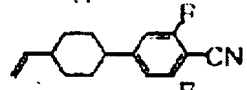
(3-0906)  5 wt%

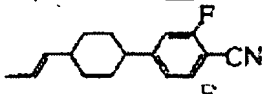
(3-0907)  5 wt%

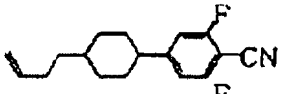
(3-0908)  5 wt%

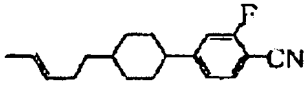
(3-0909)  5 wt%

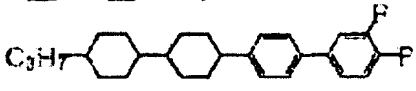
(3-0910)  5 wt%

(3-0911)  5 wt%

(3-0912)  5 wt%

(3-0913)  5 wt%

(3-0914)  5 wt%

(3-0915)  3 wt%

and various properties of this composition were measured. The

results are as follows.

T_{N-I} : 66.6

T_{-N} : -30. °C

Vth : 1.42 V

$\Delta\varepsilon$: 9.4

Δn : 0.097

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5k) to prepare a nematic liquid crystal composition (3-09-01).

[0213]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5l) to prepare a nematic liquid crystal composition (3-09-02).

[0214]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5m) to prepare a nematic liquid crystal composition (3-09-03).

[0215]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5n) to prepare a nematic liquid crystal composition (3-09-04).

[0216]

The nematic liquid crystal composition (3-0906) of

Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5o) to prepare a nematic liquid crystal composition (3-09-05).

[0217]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5p) to prepare a nematic liquid crystal composition (3-09-06).

[0218]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ag) to prepare a nematic liquid crystal composition (3-09-07).

[0219]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ah) to prepare a nematic liquid crystal composition (3-09-08).

[0220]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ai) to prepare a nematic liquid crystal composition (3-09-09).

[0221]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5aj) to prepare a

nematic liquid crystal composition (3-09-10).

[0222]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ak) to prepare a nematic liquid crystal composition (3-09-11).

[0223]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5al) to prepare a nematic liquid crystal composition (3-09-12).

[0224]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5am) to prepare a nematic liquid crystal composition (3-09-13).

[0225]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5an) to prepare a nematic liquid crystal composition (3-09-14).

[0226]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ao) to prepare a nematic liquid crystal composition (3-09-15).

[0227]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ap) to prepare a nematic liquid crystal composition (3-09-16).

[0228]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5aq) to prepare a nematic liquid crystal composition (3-09-17).

[0229]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5ar) to prepare a nematic liquid crystal composition (3-09-18).

[0230]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5as) to prepare a nematic liquid crystal composition (3-09-19).

[0231]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5at) to prepare a nematic liquid crystal composition (3-09-20).

[0232]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b),

basic structure (I-2at) and polar group (I-5au) to prepare a nematic liquid crystal composition (3-09-21).

[0233]

The nematic liquid crystal composition (3-0906) of Example 9 was replaced by a compound: side chain group (I-4b), basic structure (I-2at) and polar group (I-5av) to prepare a nematic liquid crystal composition (3-09-22).

[0234]

Using these nematic liquid crystal compositions (3-09-01) to (3-09-22), display characteristics were measured in the same manner as in Example 9. As a result, the display characteristics of these nematic liquid crystal compositions showed good results, similar to Example 9.

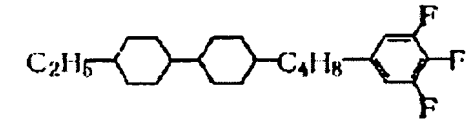
(Example 10)

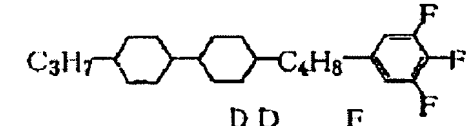
A nematic liquid crystal composition (3-10) was prepared from

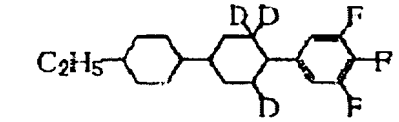
[0235]

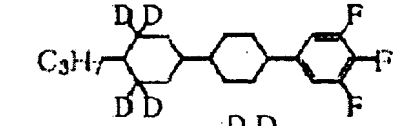
[Chemical Formula 78]

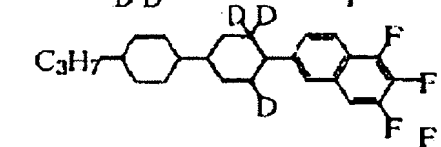
Nematic liquid crystal composition (3-10)

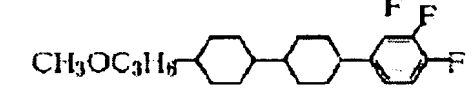
(3-1001)  10 wt %

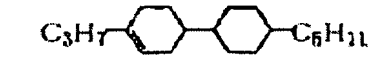
(3-1002)  10 wt %

(3-1003)  5 wt %

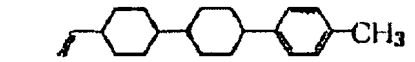
(3-1004)  5 wt %

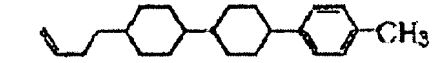
(3-1005)  10 wt %

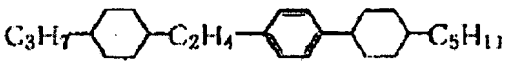
(3-1006)  10 wt %

(3-1007)  10 wt %

(3-1008)  10 wt %

(3-1009)  10 wt %

(3-1010)  10 wt %

(3-1011)  10 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 103.7°C

T_{-N} : -70. °C

Vth : 2.66 V

γ : 1.16

$\Delta\varepsilon$: 4.1

Δn : 0.079

Resistivity before heating acceleration test: 1.1×10^{13} $\Omega \cdot cm$

Resistivity after heating acceleration test: 7.3×10^{12} $\Omega \cdot cm$

Voltage holding ratio before heating acceleration test: 99.0%

Voltage holding ratio after heating acceleration test: 98.8%

Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood that high thermal stability is ensured. The active matrix liquid crystal display device that employs this composition as the basic constituent material has excellent characteristics with less leak current without occurrence of flicker.

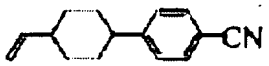
(Example 11)

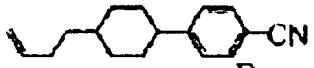
A nematic liquid crystal composition (3-11) was prepared from

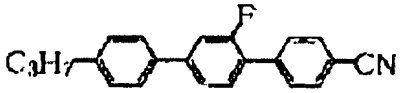
[0236]

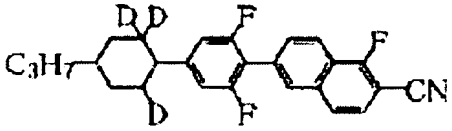
[Chemical Formula 79]

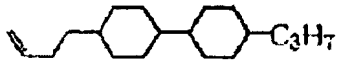
Nematic liquid crystal composition (3-11)

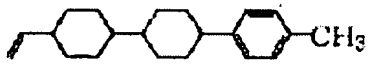
(3-1101)  12 wt %

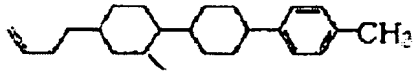
(3-1102)  10 wt %

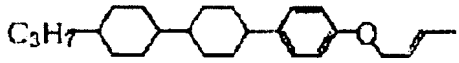
(3-1103)  9 wt %

(3-1104)  5 wt %

(3-1105)  19 wt %

(3-1106)  4 wt %

(3-1107)  13 wt %

(3-1108)  4 wt %

(3-1109)  12 wt %

(3-1110)  12 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 110.4°C

T_{-N} : -40. °C

Vth : 2.17 V

$\Delta\varepsilon$: 8.5

Δn : 0.184

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 2.39 V

γ : 1.027

$\Delta(Vth)/\Delta(T)$: 2.6 mV/°C (T=5 to 40°C)

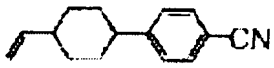
(Example 12)

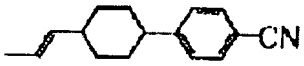
A nematic liquid crystal composition (3-12) was prepared from

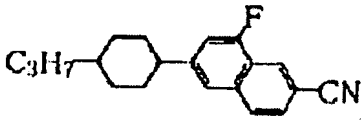
[0237]

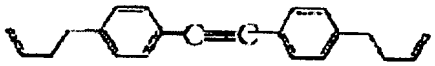
[Chemical Formula 80]

Nematic liquid crystal composition (3-12)

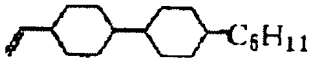
(3-1201)  5 wt %

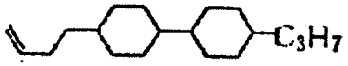
(3-1202)  12 wt %

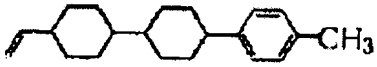
(3-1203)  10 wt %

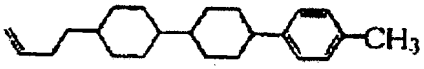
(3-1204)  12 wt %

(3-1205)  10 wt %

(3-1206)  20 wt %

(3-1207)  8 wt %

(3-1208)  11 wt %

(3-1209)  12 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 87.5°C

T_{-N} : -35. °C

Vth : 2.01 V

$\Delta\varepsilon$: 5.1

Δn : 0.154

Display characteristics of the STN-LCD having a twist angle of

240 degrees

Vth : 2.25 V

γ : 1.028

$\tau_r=\tau_d$: 98. msec. (When driven with duty ratio of 1/240)

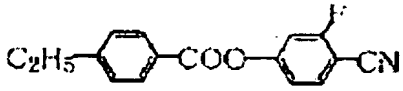
(Example 13)

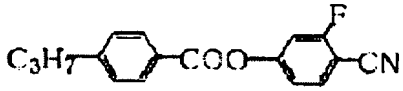
A nematic liquid crystal composition (3-13) was prepared from

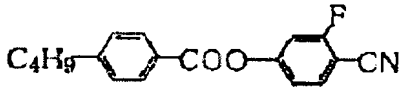
[0238]

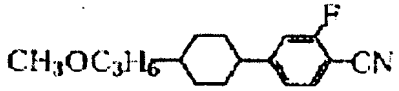
[Chemical Formula 81]

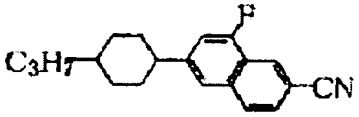
Nematic liquid crystal composition (3-13)

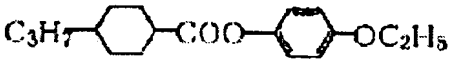
(3-1301)  8 wt %

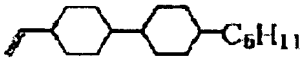
(3-1302)  5 wt %

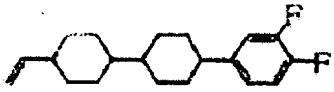
(3-1303)  12 wt %

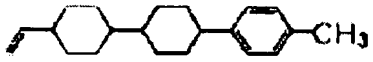
(3-1304)  2 wt %

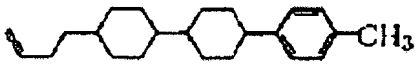
(3-1305)  8 wt %

(3-1306)  3 wt %

(3-1307)  10 wt %

(3-1308)  21 wt %

(3-1309)  9 wt %

(3-1310)  11 wt %

(3-1311)  7 wt %

(3-1312)  4 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 98.8°C

T_{-N} : -70. °C

Vth : 1.21 V

$\Delta\varepsilon$: 13.2

Δn : 0.135

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 1.28 V

γ : 1.023

$\Delta(Vth)/\Delta(T)$: 1.9mV/°C (T=5 to 40°C)

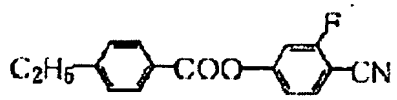
(Example 14)

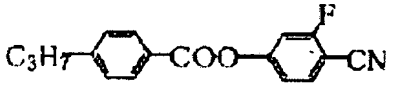
A nematic liquid crystal composition (3-14) was prepared from

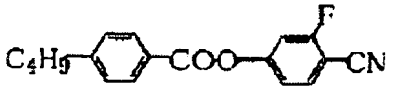
[0239]

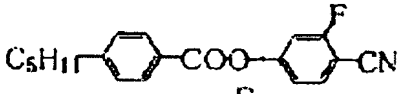
[Chemical Formula 82]

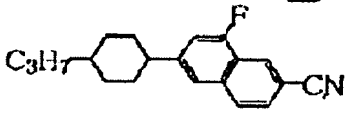
Nematic liquid crystal composition (3-14)

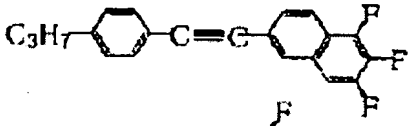
(3-1401)  8 wt %

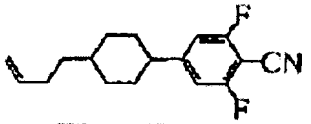
(3-1402)  5 wt %

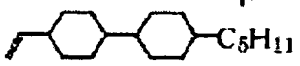
(3-1403)  16 wt %

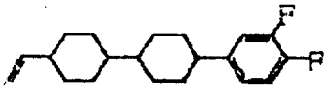
(3-1404)  7 wt %

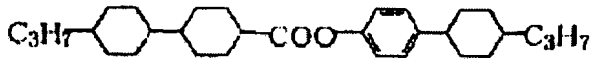
(3-1406)  11 wt %

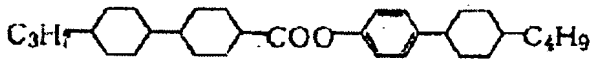
(3-1406)  7 wt %

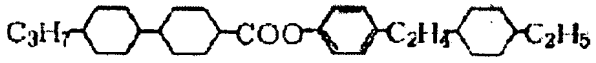
(3-1407)  3 wt %

(3-1408)  8 wt %

(3-1409)  19 wt %

(3-1410)  6 wt %

(3-1411)  6 wt %

(3-1412)  4 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 92.6°C

T_{-N} : -70. °C

Vth : 0.88 V

Δε : 19.8

Δn : 0.139

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 0.93 V

γ : 1.021

$\Delta(Vth)/\Delta(T)$: 1.9 mV/°C (T=5 to 40°C)

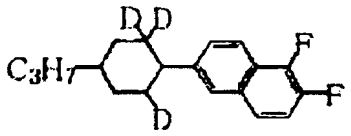
(Example 15)

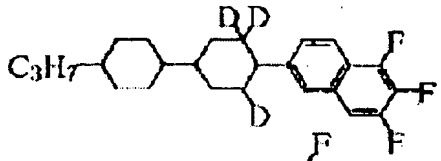
A nematic liquid crystal composition (3-15) was prepared from

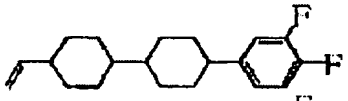
[0240]

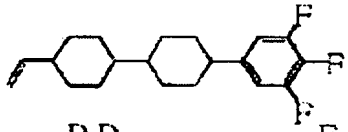
[Chemical Formula 83]

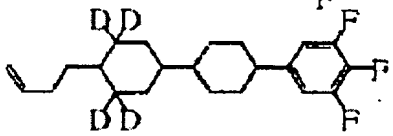
Nematic liquid crystal composition (3-15)

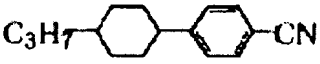
(3-1501)  5 wt%

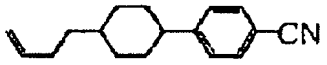
(3-1502)  5 wt%

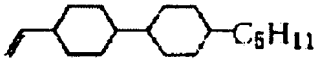
(3-1503)  10 wt%

(3-1504)  10 wt%

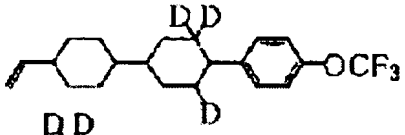
(3-1505)  10 wt%

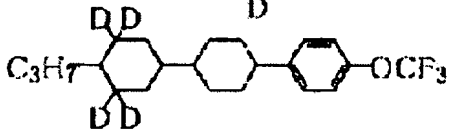
(3-1506)  10 wt%

(3-1507)  10 wt%

(3-1508)  10 wt%

(3-1509)  10 wt%

(3-1510)  10 wt%

(3-1511)  10 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 88.4°C

T_{-N} : -49. °C

Vth : 1.81 V

$\Delta\varepsilon$: 7.4

Δn : 0.098

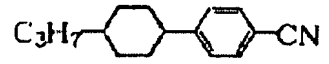
(Example 16)

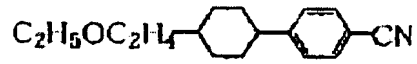
A nematic liquid crystal composition (3-16) was prepared from

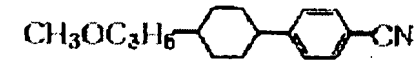
[0241]

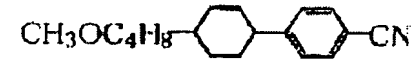
[Chemical Formula 84]

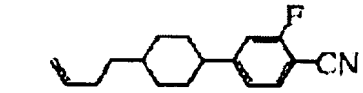
Nematic liquid crystal composition (3-16)

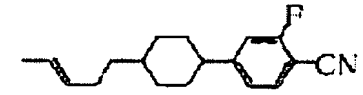
(3-1601)  10 wt %

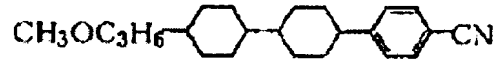
(3-1602)  10 wt %

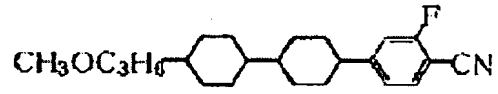
(3-1603)  16 wt %

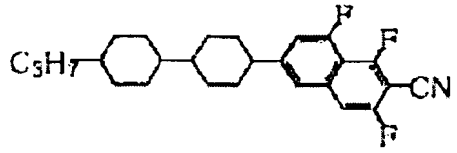
(3-1604)  15 wt %

(3-1605)  10 wt %

(3-1606)  10 wt %

(3-1607)  11 wt %

(3-1608)  11 wt %

(3-1609)  8 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 76.2°C

T_{-N} : -35. °C

Vth : 1.09 V

γ : 1.16

Δε : 21.2

Δn : 0.136

Δ(Vth)/Δ(T) : 2.3 mV/°C (T=-10 to 40°C)

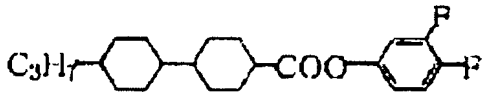
(Example 17)

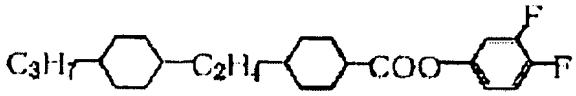
A nematic liquid crystal composition (3-17) was prepared from

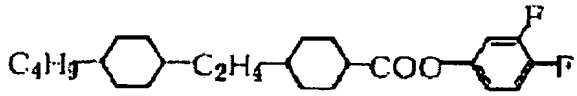
[0242]

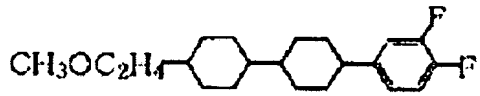
[Chemical Formula 85]

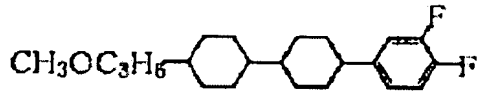
Nematic liquid crystal composition (3-17)

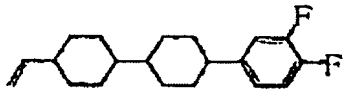
(3-1701)  10 wt%

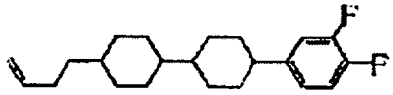
(3-1702)  10 wt %

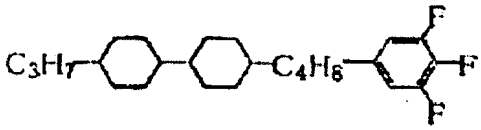
(3-1703)  10 wt %

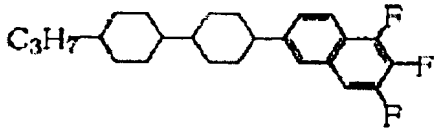
(3-1704)  10 wt %

(3-1705)  10 wt %

(3-1706)  15 wt %

(3-1707)  15 wt %

(3-1708)  10 wt %

(3-1709)  10 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 119.1°C

T_{-N} : -40. °C

Vth : 2.13 V

γ : 1.16

Δε : 6.8

Δn : 0.084

η : 31.8 c.p.

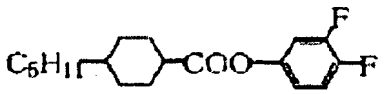
(Example 18)

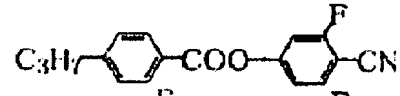
A nematic liquid crystal composition (3-18) was prepared from

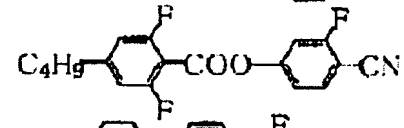
[0243]

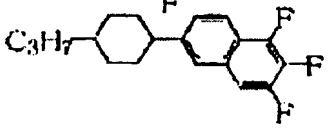
[Chemical Formula 86]

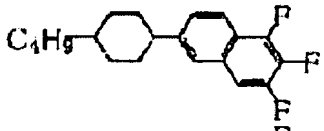
Nematic liquid crystal composition (3-18)

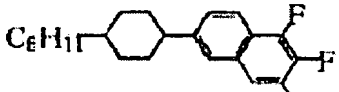
(3-1801)  10 wt%

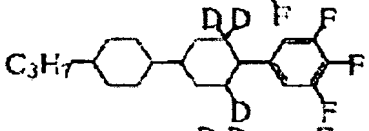
(3-1802)  5 wt%

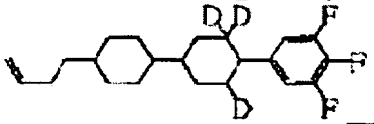
(3-1803)  5 wt%

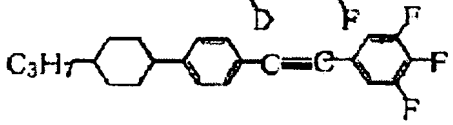
(3-1804)  5 wt%

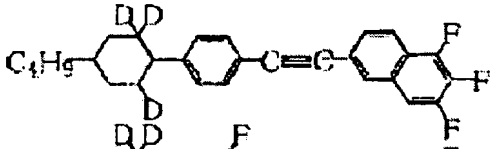
(3-1805)  10 wt%

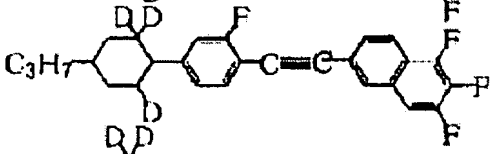
(3-1806)  10 wt%

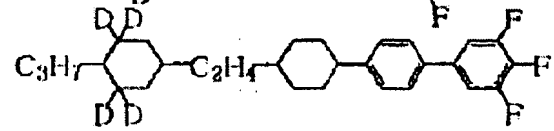
(3-1807)  7 wt%

(3-1808)  10 wt%

(3-1809)  10 wt%

(3-1810)  8 wt%

(3-1811)  10 wt%

(3-1812)  10 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 85.6°C

T_{-N} : -70. °C

Vth : 1.07 V

γ : 1.15

Δε : 17.4

Δn : 0.143

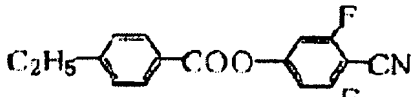
(Example 19)

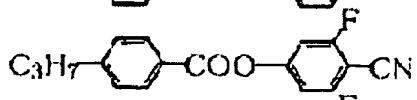
A nematic liquid crystal composition (3-19) was prepared from

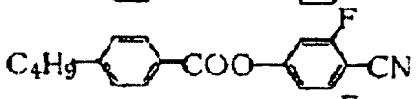
[0244]

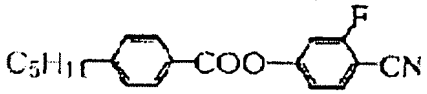
[Chemical Formula 87]

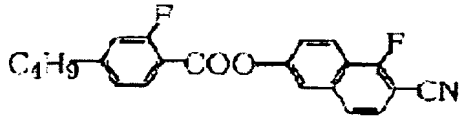
Nematic liquid crystal composition (3-19)

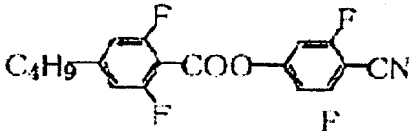
(3-1901)  8 wt %

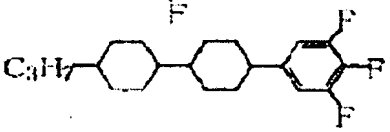
(3-1902)  5 wt %

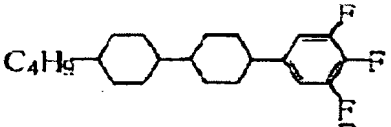
(3-1903)  15 wt %

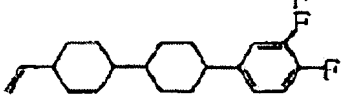
(3-1904)  4 wt %

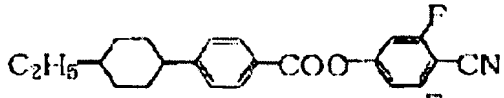
(3-1905)  4 wt %

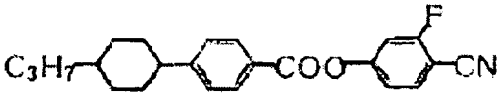
(3-1906)  4 wt %

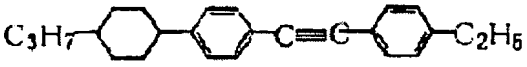
(3-1907)  10 wt %

(3-1908)  10 wt %

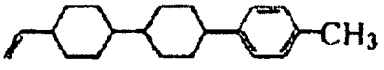
(3-1909)  11 wt %

(3-1910)  4 wt %

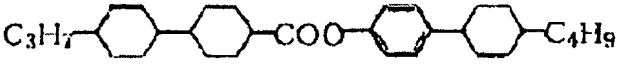
(3-1911)  6 wt %

(3-1912)  7 wt %

(3-1913)  2 wt %

(3-1914)  2 wt %

(3-1915)  4 wt %

(3-1916)  4 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 90.7°C

T_{-N} : -41. °C

Vth : 0.95 V

$\Delta\varepsilon$: 19.0

Δn : 0.142

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 0.98 V

γ : 1.021

$\Delta(Vth)/\Delta(T)$: 1.2 mV/°C (T=-20 to 40°C)

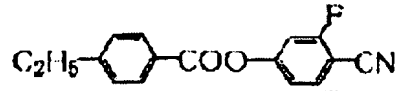
(Example 20)

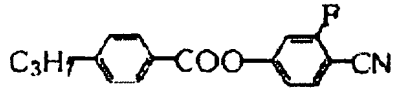
A nematic liquid crystal composition (3-20) was prepared from

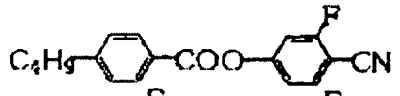
[0245]

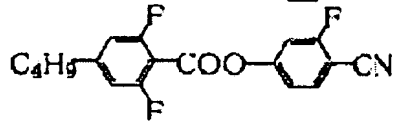
[Chemical Formula 88]

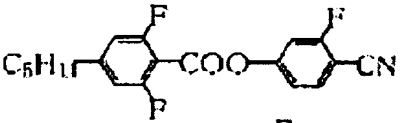
Nematic liquid crystal composition (3-20)

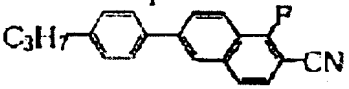
(3-2001)  8 wt %

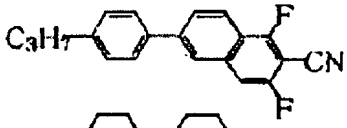
(3-2002)  5 wt %

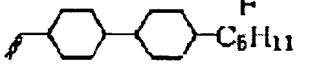
(3-2003)  9 wt %

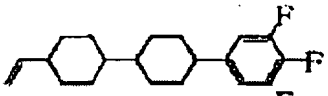
(3-2004)  5 wt %

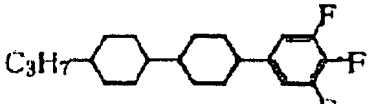
(3-2005)  5 wt %

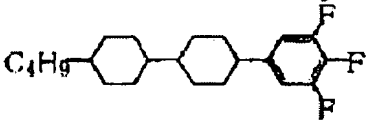
(3-2006)  12 wt %

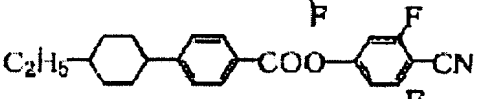
(3-2007)  5 wt %

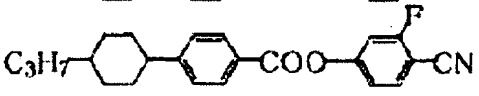
(3-2008)  10 wt %

(3-2009)  16 wt %

(3-2010)  5 wt %

(3-2011)  5 wt %

(3-2012)  6 wt %

(3-2013)  6 wt %

(3-2014)  3 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 76.5°C

T_{-N} : -70. °C

Vth : 0.82 V

$\Delta\varepsilon$: 22.2

Δn : 0.147

Display characteristics of the STN-LCD having a twist angle of 240 degrees

Vth : 0.88 V

γ : 1.020

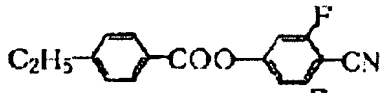
(Example 21)

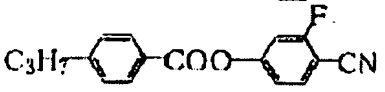
A nematic liquid crystal composition (3-21) was prepared from

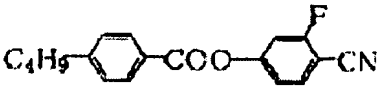
[0246]

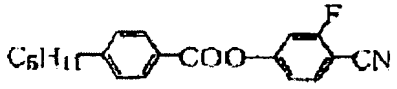
[Chemical Formula 89]

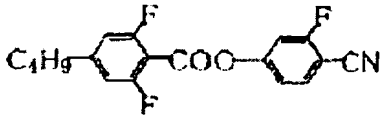
Nematic liquid crystal composition (3-21)

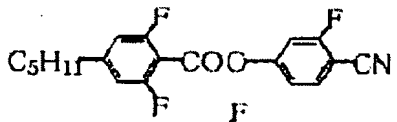
(3-2101)  8 wt%

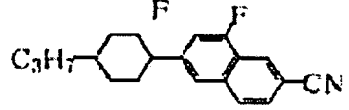
(3-2102)  5 wt %

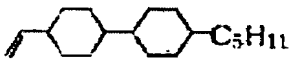
(3-2103)  16 wt %

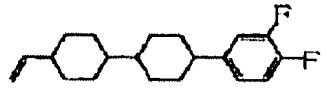
(3-2104)  7 wt %

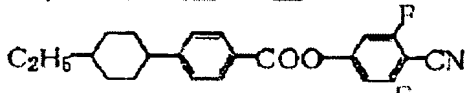
(3-2105)  5 wt %

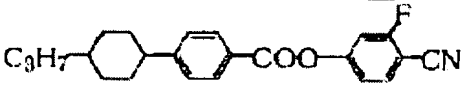
(3-2106)  5 wt %

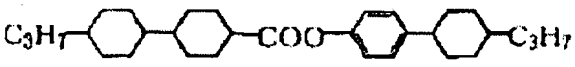
(3-2107)  10 wt %

(3-2108)  11 wt %

(3-2109)  17 wt %

(3-2110)  6 wt %

(3-2111)  7 wt %

(3-2112)  3 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 69.6°C

T_{-N} : -64. °C

Vth : 0.89 V

$\Delta\varepsilon$: 25.2

Δn : 0.136

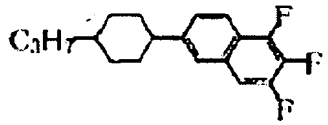
(Example 22)

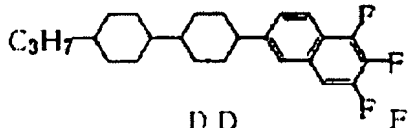
A nematic liquid crystal composition (3-22) was prepared from

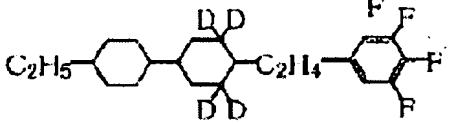
[0247]

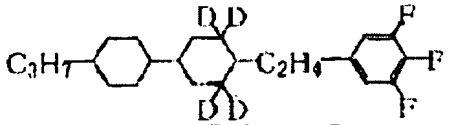
[Chemical Formula 90]

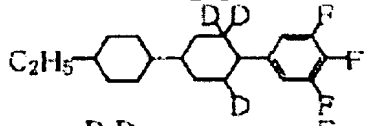
Nematic liquid crystal composition (3-22)

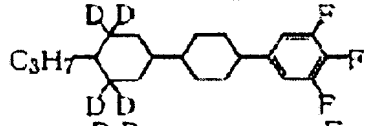
(3-2201)  10 wt%

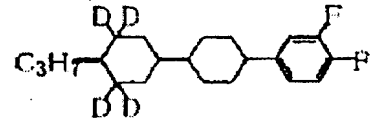
(3-2202)  10 wt %

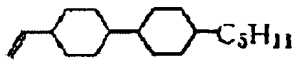
(3-2203)  5 wt %

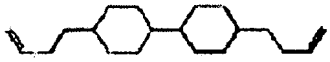
(3-2204)  5 wt %

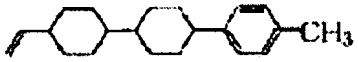
(3-2205)  5 wt %

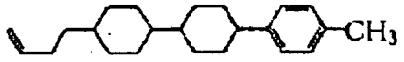
(3-2206)  5 wt %

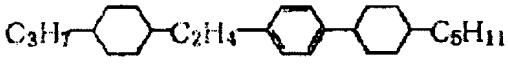
(3-2207)  10 wt %

(3-2208)  10 wt %

(3-2209)  10 wt %

(3-2210)  10 wt %

(3-2211)  10 wt %

(3-2212)  10 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 100.3°C

T_{-N} : -40. °C

Vth : 2.16 V

γ : 1.16

$\Delta\varepsilon$: 4.6

Δn : 0.083

Resistivity before heating acceleration test: 1.0×10^{13} $\Omega \cdot cm$

Resistivity after heating acceleration test: 7.0×10^{12} $\Omega \cdot cm$

Voltage holding ratio before heating acceleration test: 98.9%

Voltage holding ratio after heating acceleration test: 98.5%

Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood that high thermal stability is ensured. The active matrix liquid crystal display device that employs this composition as the basic constituent material has excellent characteristics with less leak current without occurrence of flicker.

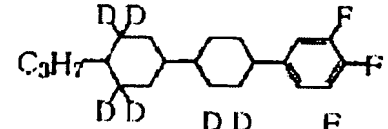
(Example 23)

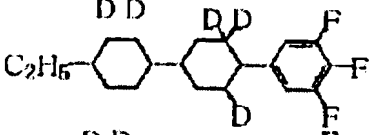
A nematic liquid crystal composition (3-23) was prepared from

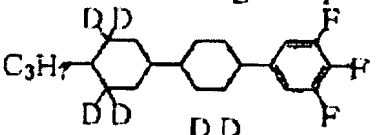
[0248]

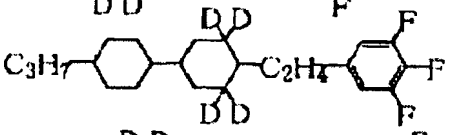
[Chemical Formula 91]

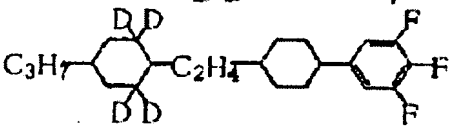
Nematic liquid crystal composition (3-23)

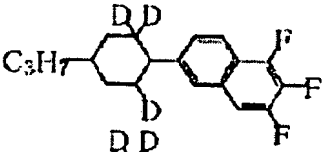
(3-2301)  12 wt %

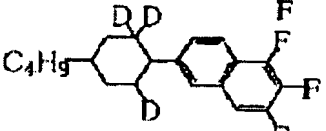
(3-2302)  6 wt %

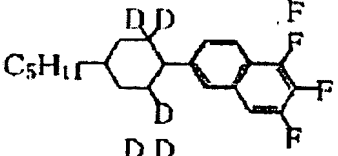
(3-2303)  6 wt %

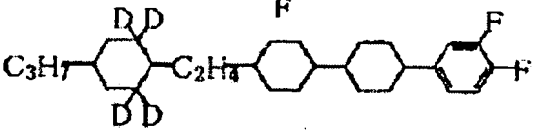
(3-2304)  12 wt %

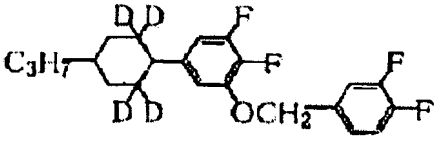
(3-2305)  12 wt %

(3-2306)  12 wt %

(3-2307)  12 wt %

(3-2308)  12 wt %

(3-2309)  12 wt %

(3-2310)  4 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 84.5°C

T_{-N} : -70. °C

Vth : 1.02 V

γ : 1.15

Δε : 9.6

Δn : 0.099

Resistivity before heating acceleration test: 5.0×10^{12} Ω·cm

Resistivity after heating acceleration test: 2.1×10^{12} Ω·cm

Voltage holding ratio before heating acceleration test: 98.8%

Voltage holding ratio after heating acceleration test: 98.5%

Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood that high thermal stability is ensured. The active matrix liquid crystal display device that employs this composition as the basic constituent material has excellent characteristics with less leak current without occurrence of flicker.

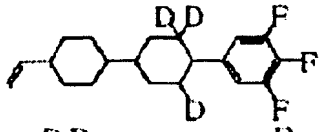
(Example 24)

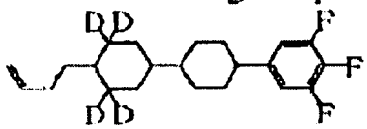
A nematic liquid crystal composition (3-24) was prepared from

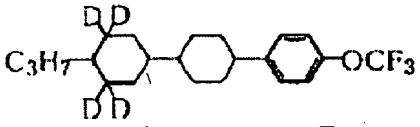
[0249]

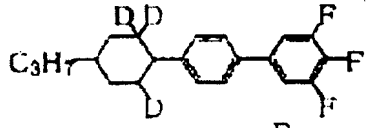
[Chemical Formula 92]

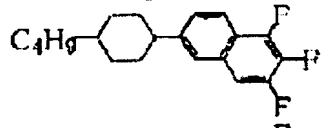
Nematic liquid crystal composition (3-24)

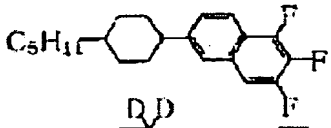
(3-2401)  15 wt %

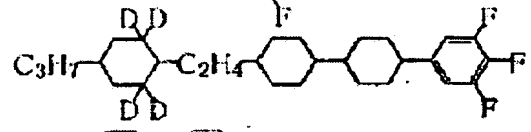
(3-2402)  10 wt %

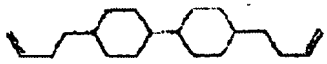
(3-2403)  10 wt %

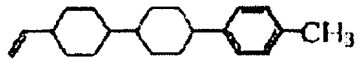
(3-2404)  5 wt %

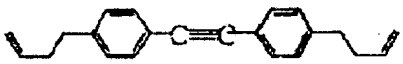
(3-2405)  10 wt %

(3-2406)  15 wt %

(3-2407)  5 wt %

(3-2408)  10 wt %

(3-2409)  10 wt %

(3-2410)  10 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 87.5°C

T_{-N} : -70. °C

Vth : 1.67 V

γ : 1.16

Δε : 7.1

Δn : 0.118

Resistivity before heating acceleration test: 3.8×10^{13} $\Omega \cdot cm$

Resistivity after heating acceleration test: 9.7×10^{12} $\Omega \cdot cm$

Voltage holding ratio before heating acceleration test: 99.1%

Voltage holding ratio after heating acceleration test: 98.8%

Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood that high thermal stability is ensured. The active matrix liquid crystal display device that employs this composition as the basic constituent material has excellent characteristics with less leak current without occurrence of flicker.

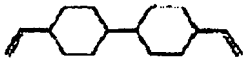
(Example 25)

A nematic liquid crystal composition (3-25) was prepared from

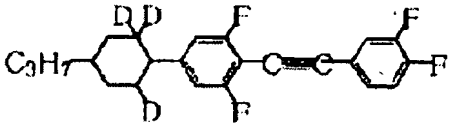
[0250]

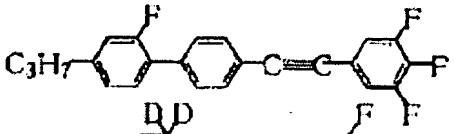
[Chemical Formula 93]

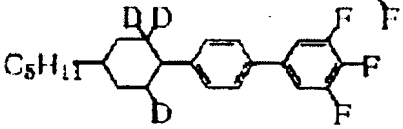
Nematic liquid crystal composition (3-25)

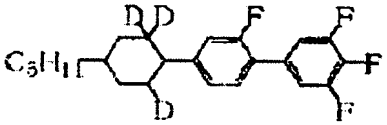
(3-2501)  10 wt %

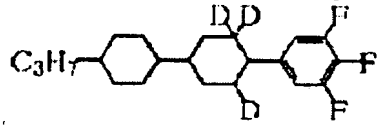
(3-2502)  10 wt %

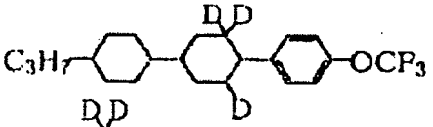
(3-2503)  15 wt %

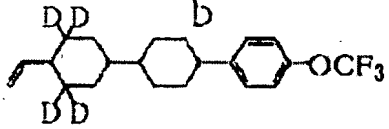
(3-2504)  10 wt %

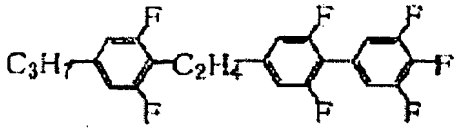
(3-2505)  10 wt %

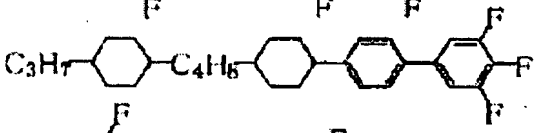
(3-2506)  5 wt %

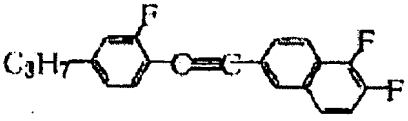
(3-2507)  5 wt %

(3-2508)  10 wt %

(3-2509)  10 wt %

(3-2510)  3 wt %

(3-2511)  5 wt %

(3-2512)  7 wt %

and various properties of this composition were measured. The results are as follows. Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood

that high thermal stability is ensured. The active matrix liquid crystal display device that employs this composition as the basic constituent material has excellent characteristics with less leak current without occurrence of flicker.

T_{N-I} : 80.0°C

T_{-N} : -70. °C

Vth : 1.38 V

γ : 1.16

$\Delta\varepsilon$: 9.3

Δn : 0.131

Resistivity before heating acceleration test: 2.2×10^{13} Ω·cm

Resistivity after heating acceleration test: 8.3×10^{12} Ω·cm

Voltage holding ratio before heating acceleration test: 99.0%

Voltage holding ratio after heating acceleration test: 98.5%

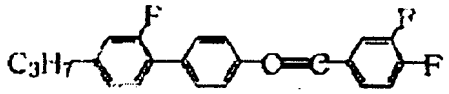
(Example 26)

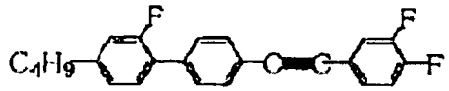
A nematic liquid crystal composition (3-26) was prepared from

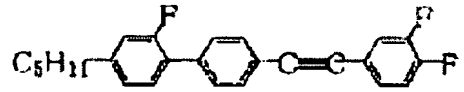
[0251]

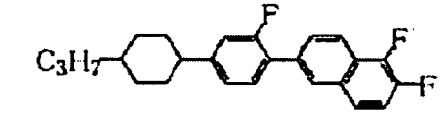
[Chemical Formula 94]

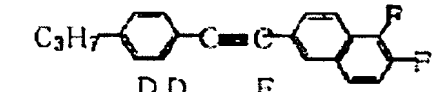
Nematic liquid crystal composition (3-26)

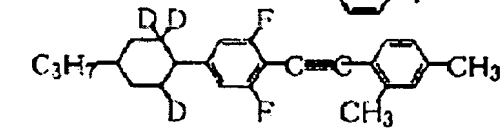
(3-2601)  15 wt %

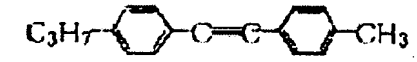
(3-2602)  15 wt %

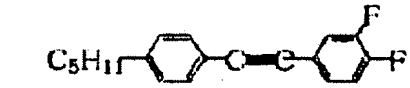
(3-2603)  15 wt %

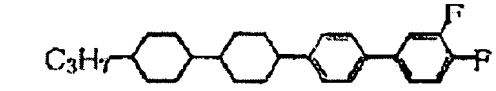
(3-2604)  13 wt %

(3-2605)  7 wt %

(3-2606)  13 wt %

(3-2607)  15 wt %

(3-2608)  5 wt %

(3-2609)  2 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 106.4°C

T_{-N} : -20. °C

Vth : 2.10 V

Y : 1.15

Δε : 8.1

Δn : 0.276

Resistivity before heating acceleration test: 6.5×10^{12} Ω·cm

Resistivity after heating acceleration test: 1.2×10^{12} Ω·cm

Voltage holding ratio before heating acceleration test: 98.8%

Voltage holding ratio after heating acceleration test: 98.0%

Because this nematic liquid crystal composition has high resistivity and high voltage holding ratio after heating acceleration test, it can be understood that high thermal stability is ensured. Also it is possible to prepare a nematic liquid crystal composition that employs this composition as the basic constituent material of the present invention, and to utilize the nematic liquid crystal composition for an active matrix liquid crystal display device using the same.

[0252]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1h) and polar group (I-5j) to prepare a nematic liquid crystal composition (3-026-01).

[0253]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1i) and polar group (I-5j) to prepare a nematic liquid crystal composition (3-026-02).

[0254]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1g) and polar group (I-5k) to prepare a nematic liquid crystal composition (3-026-03).

[0255]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1g) and polar group (I-5r) to prepare a nematic liquid crystal composition (3-026-04).

[0256]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1g) and polar group (I-5z) to prepare a nematic liquid crystal composition (3-026-05).

[0257]

The nematic liquid crystal composition (3-2605) of Example 26 was replaced by a compound: side chain group (I-4b), basic structure (I-1g) and polar group (I-5ah) to prepare a nematic liquid crystal composition (3-026-06).

[0258]

Using these nematic liquid crystal compositions (3-26-01) to (3-26-06), display characteristics were measured in the same manner as in Example 26. As a result, the display characteristics of these nematic liquid crystal compositions showed good results, similar to Example 26.

[0259]

This nematic liquid crystal composition was used to make TN-LCD having cell thickness d of 1.8 μm and display characteristics thereof were measured. A liquid crystal display device having a threshold voltage of 1.79 V and a response speed of 2.4 msec. was obtained.

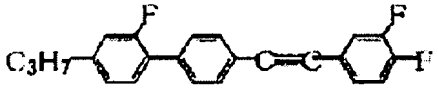
(Example 27)

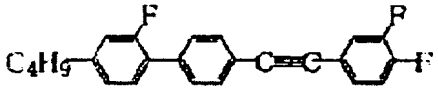
A nematic liquid crystal composition (3-27) was prepared from

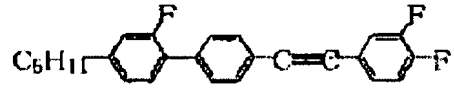
[0260]

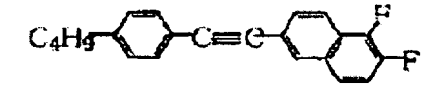
[Chemical Formula 95]

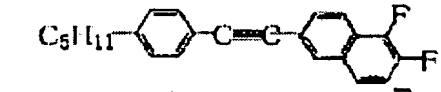
Nematic liquid crystal composition (3-27)

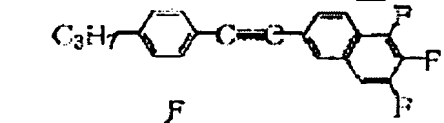
(3-2701)  5 wt %

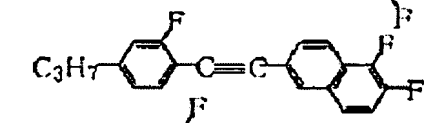
(3-2702)  5 wt %

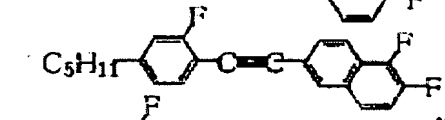
(3-2703)  5 wt %

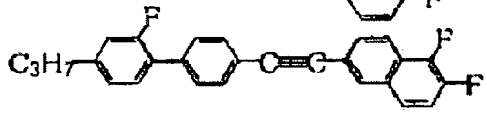
(3-2704)  5 wt %

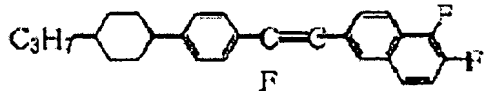
(3-2705)  5 wt %

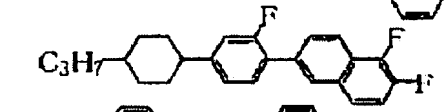
(3-2706)  5 wt %

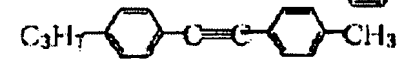
(3-2707)  5 wt %

(3-2708)  5 wt %

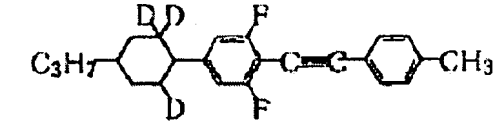
(3-2709)  5 wt %

(3-2710)  5 wt %

(3-2711)  5 wt %

(3-2712)  15 wt %

(3-2713)  15 wt %

(3-2714)  15 wt %

and various properties of this composition were measured.

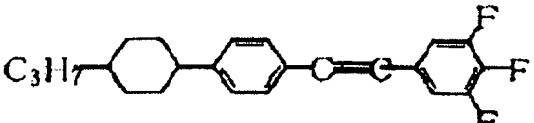
(Example 28)

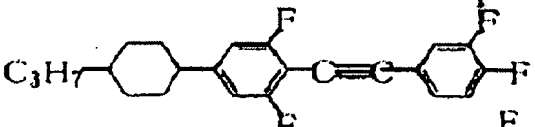
A nematic liquid crystal composition (3-28) was prepared from

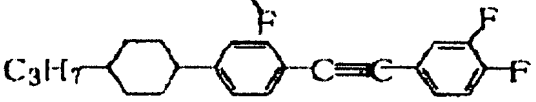
[0261]

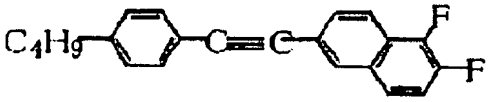
[Chemical Formula 96]

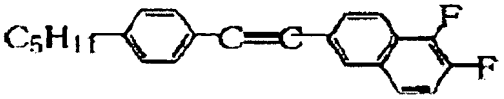
Nematic liquid crystal composition (3-28)

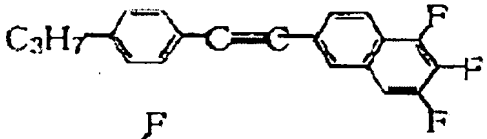
(3-2801)  5 wt %

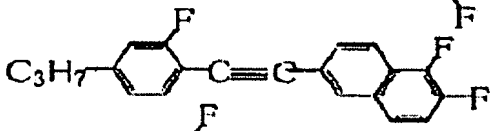
(3-2802)  5 wt %

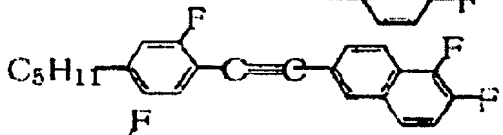
(3-2803)  5 wt %

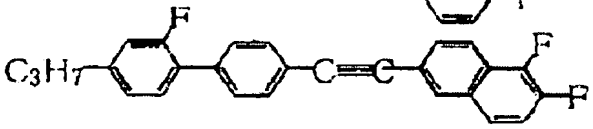
(3-2804)  5 wt %

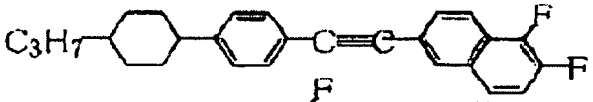
(3-2805)  5 wt %

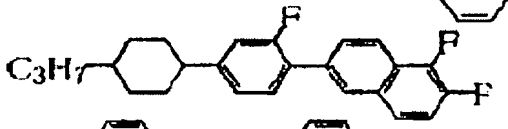
(3-2806)  5 wt %

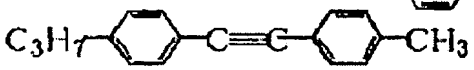
(3-2807)  5 wt %

(3-2808)  5 wt %

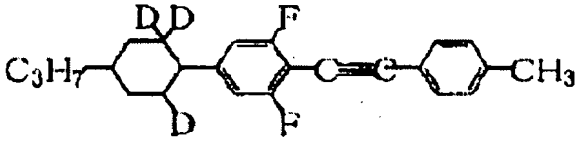
(3-2809)  5 wt %

(3-2810)  5 wt %

(3-2811)  5 wt %

(3-2812)  15 wt %

(3-2813)  15 wt %

(3-2814)  15 wt %

and various properties of this composition were measured.

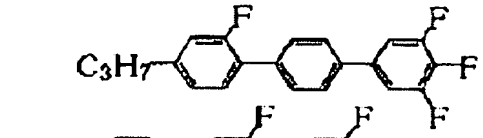
(Example 29)

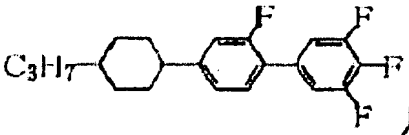
A nematic liquid crystal composition (3-29) was prepared from

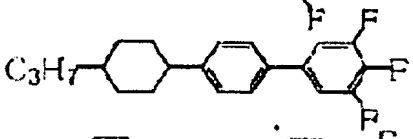
[0262]

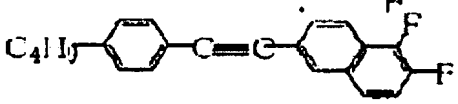
[Chemical Formula 97]

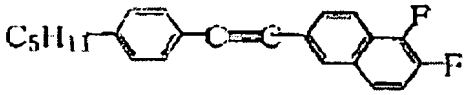
Nematic liquid crystal composition (3-29)

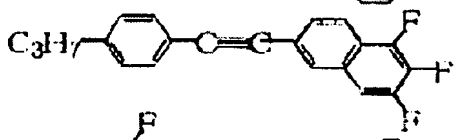
(3-2901)  5 wt%

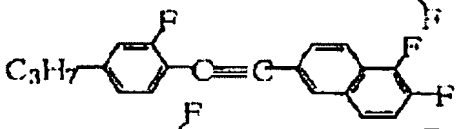
(3-2902)  5 wt%

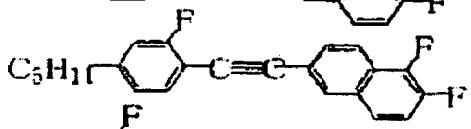
(3-2903)  5 wt%

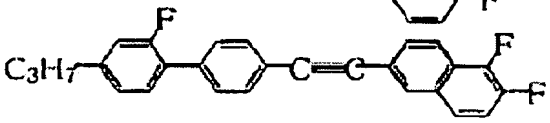
(3-2904)  5 wt%

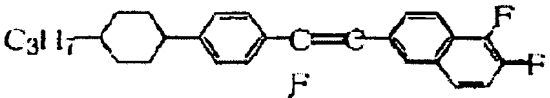
(3-2905)  5 wt%

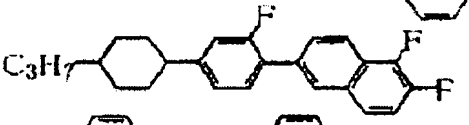
(3-2906)  5 wt%

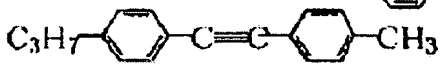
(3-2907)  5 wt%

(3-2908)  5 wt%

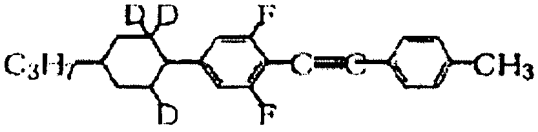
(3-2909)  5 wt%

(3-2910)  5 wt%

(3-2911)  5 wt%

(3-2912)  15 wt%

(3-2913)  15 wt%

(3-2914)  15 wt%

and various properties of this composition were measured.

[0263]

The nematic liquid crystal compositions (3-27) to (3-29) can be used for the same liquid crystal device as that of Example 26 because they have the same properties as those of

the nematic liquid crystal composition (3-26).

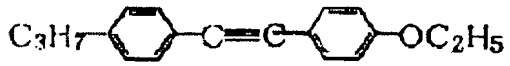
(Example 30)

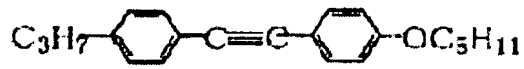
A nematic liquid crystal composition (3-30) was prepared from

[0264]

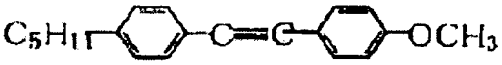
[Chemical Formula 98]

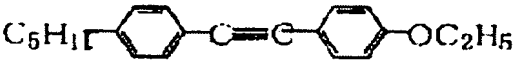
Nematic liquid crystal composition (3-30)

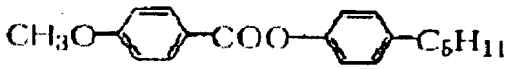
(3-3001)  10 wt %

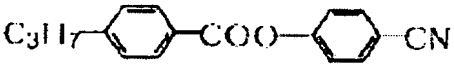
(3-3002)  10 wt %

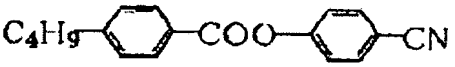
(3-3003)  8 wt %

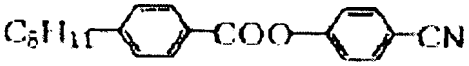
(3-3004)  8 wt %

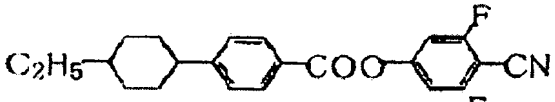
(3-3005)  10 wt %

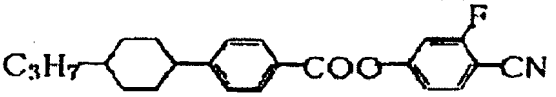
(3-3006)  12 wt %

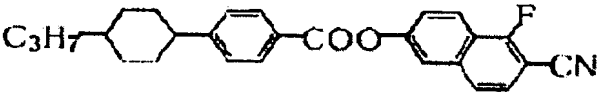
(3-3007)  6 wt %

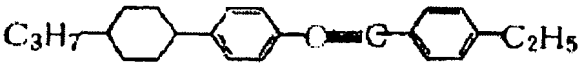
(3-3008)  10 wt %

(3-3009)  6 wt %

(3-3010)  6 wt %

(3-3011)  6 wt %

(3-3012)  4 wt %

(3-3013)  4 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 83.1°C

T_{-N} : -3. °C

Vth : 1.49 V

γ : 1.154

$\Delta\varepsilon$: 15.6

Δn : 0.224

This nematic liquid crystal composition was used to make TN-LCD having cell thickness d of 2.2 μm and display characteristics thereof were measured. A liquid crystal display device having a threshold voltage of 1.24 V and a response speed of 2.1 msec. was obtained.

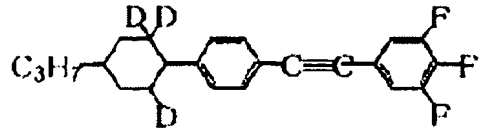
(Example 31)

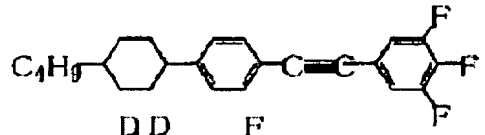
A nematic liquid crystal composition (3-31) was prepared from

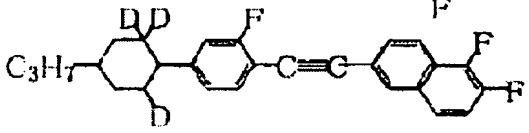
[0265]

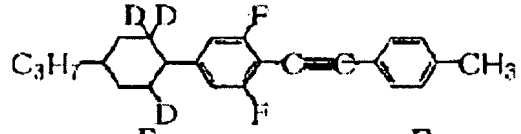
[Chemical Formula 99]

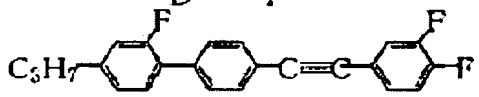
Nematic liquid crystal composition (3-31)

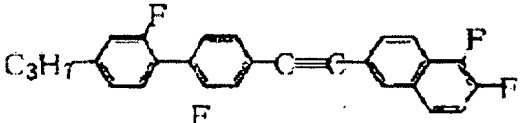
(3-3101)  10 wt %

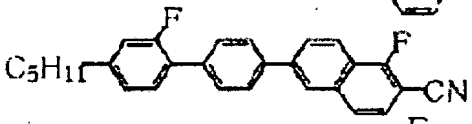
(3-3102)  10 wt %

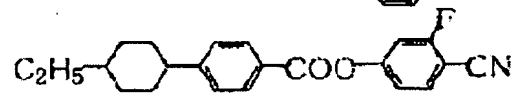
(3-3103)  10 wt %

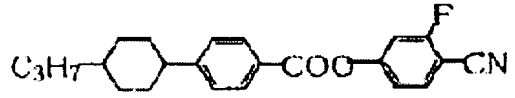
(3-3104)  5 wt %

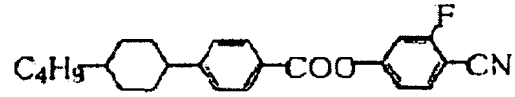
(3-3105)  10 wt %

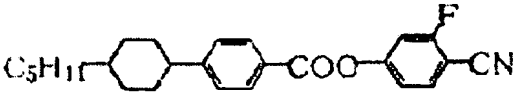
(3-3106)  5 wt %

(3-3107)  10 wt %

(3-3108)  10 wt %

(3-3109)  10 wt %

(3-3110)  10 wt %

(3-3111)  10 wt %

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 179.3°C

T_{-N} : -20. °C

Vth : 1.21 V

Δε : 30.3

Δn : 0.254

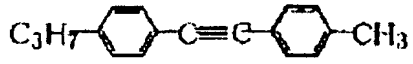
(Example 32)

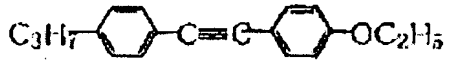
A nematic liquid crystal composition (3-32) was prepared from

[0266]

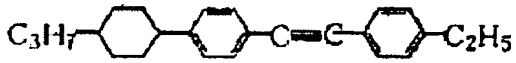
[Chemical Formula 100]

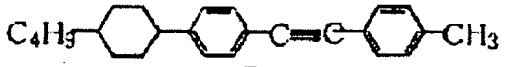
Nematic liquid crystal composition (3-32)

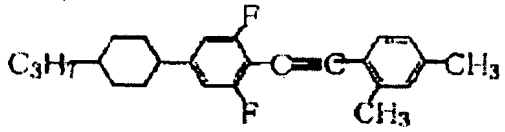
(3-3201)  20 wt%

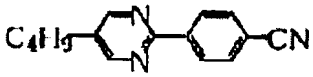
(3-3202)  10 wt%

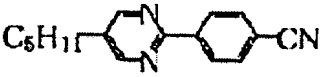
(3-3203)  5 wt%

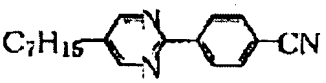
(3-3204)  7 wt%

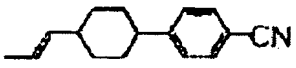
(3-3205)  8 wt%

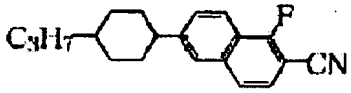
(3-3206)  10 wt%

(3-3207)  6 wt%

(3-3208)  7 wt%

(3-3209)  7 wt%

(3-3210)  10 wt%

(3-3211)  10 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 76.9°C

T_{-N} : -70. °C

Vth : 1.57 V

γ : 1.16

Δε : 10.4

Δn : 0.228

This nematic liquid crystal composition was used to make TN-LCD having cell thickness d of 2.2 μm and display characteristics thereof were measured. A liquid crystal display device having a threshold voltage of 1.32 V and a response speed of 2.2 msec. was obtained.

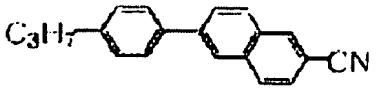
(Example 33)

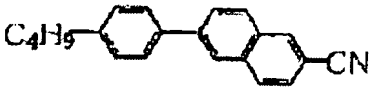
A nematic liquid crystal composition (3-33) was prepared from

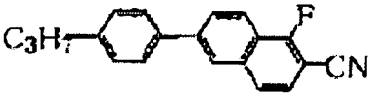
[0267]

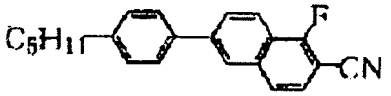
[Chemical Formula 101]

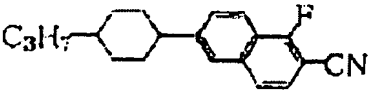
Nematic liquid crystal composition (3-33)

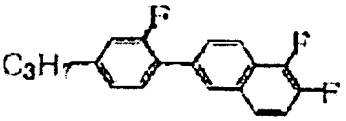
(3-3301)  9 wt%

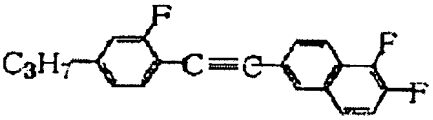
(3-3302)  8 wt%

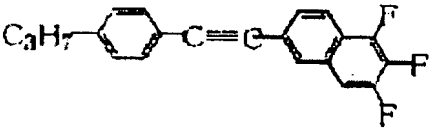
(3-3303)  8 wt%

(3-3304)  8 wt%

(3-3305)  17 wt%

(3-3306)  17 wt%

(3-3307)  17 wt%

(3-3308)  16 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 65.8°C

T_{-N} : -20. °C

Vth : 1.00 V

γ : 1.15

Δε : 19.4

Δn : 0.244

(Comparative Example 2)

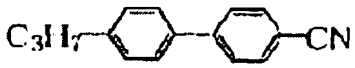
In order to demonstrate the superiority of the present invention, a mixed liquid crystal (b-02) made by substituting

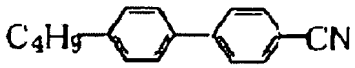
the liquid crystal component A of the nematic liquid crystal composition (3-32) described above with another compound. Specifically, the compound was replaced by a compound in which naphthalene-2,6-diyl was substituted with 1,4-phenylene.

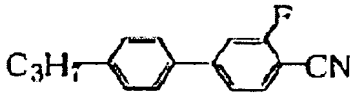
[0268]

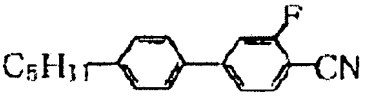
[Chemical Formula 102]

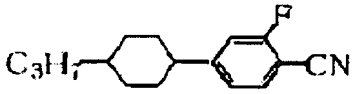
Comparative liquid crystal (b-02)

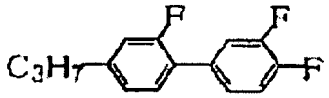
(b-0201)  9 wt%

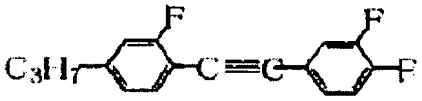
(b-0202)  8 wt%

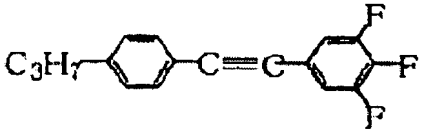
(b-0203)  8 wt%

(b-0204)  8 wt%

(b-0205)  17 wt%

(b-0206)  17 wt%

(b-0207)  17 wt%

(b-0208)  16 wt%

Properties of this composition were measured. The results are as follows.

T_{N-I} : Room temperature or lower

Vth : Impossible to measure

γ : Impossible to measure

Δε : Impossible to measure

Δn : Impossible to measure

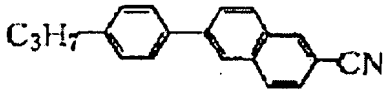
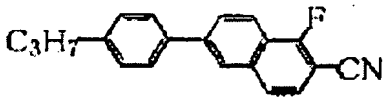
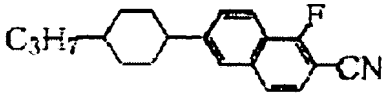
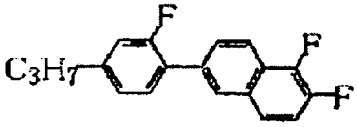
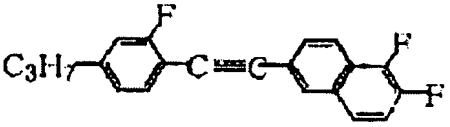
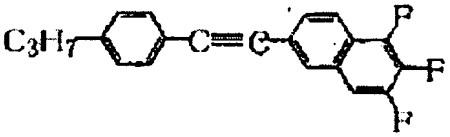
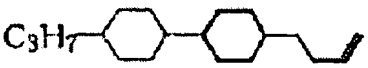
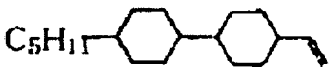
(Example 34)

A nematic liquid crystal composition (3-34) was prepared from

[0269]

[Chemical Formula 103]

Nematic liquid crystal composition (3-34)

(3-3401)		12 wt%
(3-3402)		12 wt%
(3-3403)		11 wt%
(3-3404)		12 wt%
(3-3405)		12 wt%
(3-3406)		11 wt%
(3-3407)		15 wt%
(3-3408)		15 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 66.8°C

T_{-N} : -20. °C

Vth : 1.29 V

γ : 1.18

Δε : 13.4

Δn : 0.185

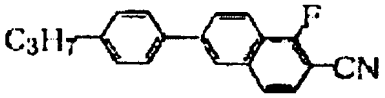
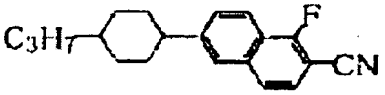
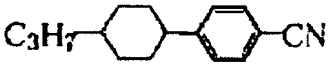
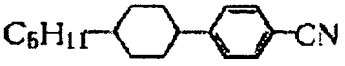
(Example 35)

A nematic liquid crystal composition (3-35) was prepared from

[0270]

[Chemical Formula 104]

Nematic liquid crystal composition (3-35)

(3-3501)		15 wt%
(3-3502)		15 wt%
(3-3503)		28 wt%
(3-3504)		21 wt%
(3-3505)		21 wt%

and various properties of this composition were measured. The results are as follows.

T_{N-I} : 65.3°C

T_{-N} : -58. °C

Vth : 1.45 V

γ : 1.17

Δε : 13.7

Δn : 0.157

(Example 36)

The nematic liquid crystal compositions of the present invention (3-17) and (3-26) to (3-32) can be used in light scattering type liquid crystal display. Application Examples will be described in detail below. It should be understood, however, that the present invention is not limited to these Examples.

[0271]

A light modulation layer forming material of uniform solution was prepared by mixing 80% of the liquid crystal composition described above as the liquid crystal material, 13.86% of HX-220 (manufactured by Nippon Kayaku Co., Ltd.) as a polymer-forming compound, 5.94% of lauryl acrylate, and 0.2% of 2-hydroxy-2-methyl-1-phenylpropan-1-one as a polymerization initiator. An empty cell measuring 50×50 mm, that was formed by two ITO electrode glass substrates with spacers having mean particle size of 10 μm interposed therebetween, was filled with this light modulation layer forming material in vacuum at a temperature 10°C higher than transition temperature of the uniform solution. This assembly was, with the temperature being kept 3°C higher than transition temperature of the uniform solution, passed under a metal halide lamp (80 W/m^2) at a speed of 3.5 m/min, while irradiating with ultraviolet rays having energy density of 500 mJ/cm^2 to cure the polymer forming compound, thereby to make a liquid crystal device having a light modulation layer consisting of the liquid crystal material and a transparent solid substance. Cut

surface of the cured material, that was formed between the substrates of the liquid crystal device thus obtained, was observed with a scanning electron microscope, and the transparent solid substance formed in three-dimensional network structure from a polymer was recognized.

[0272]

The light scattering type liquid crystal display thus obtained operates in a wider temperature range than the light scattering type liquid crystal display of the prior art, shows response characteristic that is favorable for the display of moving pictures, and has high contrast and uniform display characteristics, indicating the usefulness for outdoor information panels such as sign board, display of clock, projection display apparatus and so on. Use of the nematic liquid crystal composition (3-17) enables display characteristics with reduce haze, use of the nematic liquid crystal compositions (3-26) to (3-29) is particularly useful for active addressing, use of the nematic liquid crystal compositions (3-30) and (3-32) is useful for multiplexing drive and use of the nematic liquid crystal composition (3-31) is useful for high-temperature applications such as illumination apparatuses and laser addressing.

(Example 37)

The nematic liquid crystal compositions of the present invention, particularly (3-26) to (3-32) further have the following features. Measurement of chromatic dispersion of birefringent index of these nematic liquid crystal

compositions showed greater dispersion between wavelength 650 nm and 400 nm, with values of 1.15 and greater in some compositions. Such a liquid crystal material shows greater phase difference due to the difference in the wavelength of light, and is therefore useful for the new reflective type color liquid crystal display device that is based on the birefringence of the liquid crystal and the retardation plate and provides color display without using color filters.

[0273]

The nematic liquid crystal compositions of the present invention, particularly (3-13) to (3-15), (3-18) to (3-22) and (3-23) further have the following features.

[0274]

Assume the relaxation frequency given as $\omega d = 2\times10^{12}\times S^{-1.4031}$ defined in terms of the liquid crystal constitution factor $S = (\eta\times\langle a\rangle^3)^{-1}$ (η represents the viscosity (in cp) of the liquid crystal composition and $\langle a\rangle$ represents the mean molecular length (in Å)), and assume that effective frequency F which acts on the liquid crystal display is determined by the frame frequency of the driving voltage applied to the liquid crystal composition or by the duty number. Then relation of inequality $1.0\times10^2 \geq \omega d/F \geq 5.0\times10^{-1}$ holds in the range of the operating temperatures. Thus it can be seen that the driving voltage does not vary in the range of frequencies that correspond to various time division schemes, or the driving voltage can be suppressed from increasing sharply in a low temperature region when the frequency of time division

(duty number) increases. Such a characteristic is supposedly due to the molecular structure of a decahydronaphthalene-2,6-diyl group. As a result, use of the liquid crystal composition of the present invention makes it possible to make a liquid crystal display device having improved display characteristics. Better drive characteristic and better display characteristics were obtained with TN-LCD type and STN-LCD type liquid crystal display devices that process particularly large amount of information.

[0275]

[Effects of the Invention]

The nematic liquid crystal compositions of the present invention include, as an essential component, the liquid crystal component A that consists of the compounds represented by the general formulas (I-1) to (III-3) and, when mixed in the liquid crystal composition, such effects as the extended range of operating temperatures of the liquid crystal display due to the improvements in the co-solubility and in the storage at low-temperatures, reduction in the driving voltage, improvement in the temperature dependence of the driving voltage and thereby achieving relatively fast response characteristic for a predetermined driving voltage. The design and temperature dependence of the birefringent index, dielectric constant anisotropy and elastic constant, light wavelength dependence of the birefringent index and frequency dependence of the dielectric constant anisotropy can also be improved.

[0276]

As a result, the nematic liquid crystal compositions of the present invention can be used in a liquid crystal display device of active matrix type, twisted nematic or super twisted nematic type. Also the present invention can provide a liquid crystal display element that provides color display by utilizing birefringence of the liquid crystal layer and retardation plate. Moreover, such an apparatus can be provided that is useful for light scattering type liquid crystal display having a light modulation layer which includes the liquid crystal material and the transparent solid substance.

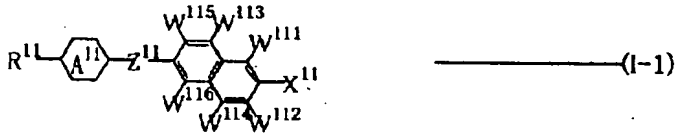
[Document Type] Abstract

[Abstract]

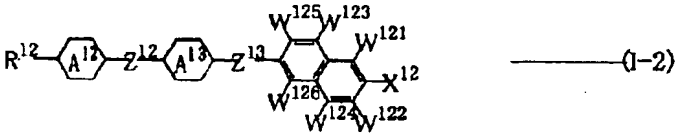
[Problmes to be Solved by the Invention] To extend the operating temperature of the liquid crystal display by making improvements in the co-solubility and in the storage at low temperature, and to remedy the reduction in driving voltage and the change in temperature, thereby to attain comparatively fast response characteristics or to improve the response characteristics for a predetermined driving voltage.

[Means for Solving the Problems] The present invention provides a nematic liquid crystal composition comprising a liquid crystal component A represented by the general formulas (I-1) to (I-3):

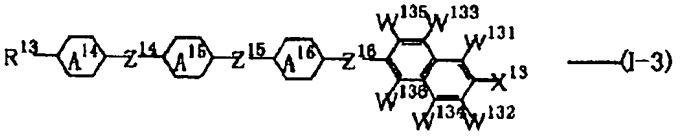
[Chemical Formula 1]



(I-1)



(I-2)



(I-3)

; 0 to 99.9% by weight of a liquid crystal component B having $\Delta\varepsilon$ of +2 or more; and 0 to 85% by weight of a liquid crystal component C composed of a compound having $\Delta\varepsilon$ within a range from -10 to +2; the sum total of said liquid crystal component B and said liquid crystal component C being within a range

from 0 to 99.9% by weight; and a liquid crystal device using the same.

[Elected Drawing] None